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Superphosphate Requirements for Growing Wheat in Western Australia.

L. J. H. TEAKLE and H. G. CARISS.

A.—SUMMARY.

1. Since the establishment of the research stations, commencing with the Chapman Experimental Farm in 1902, experiments have been conducted to determine the most satisfactory rate of application of superphosphate for wheat growing. These stations cover a wide range of soil and climatic conditions which are briefly described in the text, and are representative of the wheat belt of Western Australia. The main series of experiments discussed were commenced in 1929, and are being continued at the present time.

A number of experiments have been carried out on private farms with similar results.

2. A wide range of superphosphate applications has been used in these experiments, and from the data provided the most payable dressings for wheat growing under wheat belt conditions can be determined after allowing for the cost of superphosphate and the price of wheat. The probable yields under other rates can be predicted from an examination of the yield data illustrated in curves presented in the paper.

3. From the results of the 1929 series the most payable applications of superphosphate (22% P_2O_5) on the Research Stations appear to be:—

Chapman	80 lbs. per acre.
Dampawah	100 lbs. per acre.
Wongan Hills	130 lbs. per acre.
Merredin	110 lbs. per acre.
Yilgarn	130 lbs. per acre.
Salmon Gums	110 lbs. per acre.

These rates closely approximate those adopted on the research stations for bulk crops.

Experiments commenced in 1941 show these applications are now generous, as considerable improvement in the phosphate status of the soil has resulted from the superphosphate applications under the cropping programme since 1929. These new experiments show that the rate of superphosphate applications on old well-fertilised land may be reduced below the figures suggested above without reduction in monetary return.

4. The wheat crop in Western Australia on the average absorbs less than one-third of the phosphate in the normal superphosphate applications used in wheat growing. The residue of the phosphate is not washed out by the rains, but is held in the soil in a condition in which it is slowly available to the wheat crop and succeeding pasture crops. As the amount of superphosphate applied is increased the residues in the soil increase and the availability of these residues improves.

5. The effect of the residues of only a few hundredweights of superphosphate applied in the previous cropping programme is very marked.

On normal soils it is desirable to apply superphosphate as generously as possible with the early crops to build up phosphate reserves quickly. If necessary, economy can then be practised with little loss.

6. On plots sown without superphosphate, the growth and maturity of the wheat has been delayed, but yields of grain reported in this paper have been surprisingly good.

7. The application of superphosphate at the seeding time, even of very small amounts when adequate supplies are not available, is advised. The early growth is improved and the maturity hastened. This may be very important in unfavourable seasons.

8. To make best use of the superphosphate ration available for wheat growing, farmers are advised to spread it over the area for which it is allocated, in order to obtain the maximum benefit from the early growth stimulation and earlier maturity. Only the most satisfactory land, which has been well prepared and has been well fertilised with superphosphate in the past, should be cropped, under the acreage restrictions, to get utmost advantage from the superphosphate residues in the soil.

It is recognised that generous use of superphosphate can never compensate for unsatisfactory farming methods or adverse seasonal conditions.

B.—INTRODUCTION.

In their natural state the soils of Western Australia are notoriously deficient in available phosphate and the use of phosphatic fertilisers, chiefly high-grade superphosphate, is standard practice on practically all farms and for most crops.

With respect to the wheatbelt, the need for available phosphate is as general as elsewhere. The seeding machinery is all equipped for the application of superphosphate with the seed. Farmers generally consider seeding and fertilising as a single indivisible operation.

So spectacular have been the responses to superphosphate on many types of new land, that is, land which has not previously carried a crop, that reduction in the supply of superphosphate occasioned by the war has caused grave concern. Many farmers believe that the result will be a disastrous reduction in the yield of wheat, even on old, well-fertilised land.

Fortunately, these fears are groundless as far as old, well-fertilised land is concerned because the residual value of superphosphate applications is high. It is realised that reduction of superphosphate applications below those normally used, 90-100 lbs. per acre may cause reduced yield of wheat, but the reduction will not be large, at least for a number of crops, and a crop failure, due to lack of superphosphate, need not be feared.

It is very fortunate that the effect of various rates of superphosphate on the yield of wheat has been studied over a considerable period of years on the agricul-

tural research stations in the wheatbelt. These cover a representative range of soils and climatic conditions. Briefly these may be summarised as follows:—

Chapman Research Station (Established 1902).

The Chapman Research Station lies in the northern part of the wheatbelt in the Upper Chapman Valley and is about 28 miles north-east of Geraldton. The soils are of the red-brown earth group and are representative of the lighter soils of the jam (*Acacia acuminata*), and York gum (*Eucalyptus foecunda* var. *loxophleba*) belt of the State. However, the range of soils includes loam associated with York Gum and flooded gum (*E. rudis*), loamy sand associated with jam and wattle (*Acacia spp.*) vegetation, and sandy and gravelly soils of the heaths.

The rainfall (1906-1942), averaged 18.25 inches of which 15.55 inches fell in the May to October, or growing, period. The seasonal rainfall is somewhat variable. The country represented by this station lends itself to mixed farming, with the emphasis on livestock and pasture improvement, rather than wheat growing.

Dampawah Research Station (Established 1926: closed 1940).

The Dampawah Research Station lies on the fringe of the "mulga"* belt. This country has not been regarded as agricultural, but is devoted almost entirely to sheep raising for wool production. The research station was established to test the capabilities for wheat growing and was located some 30 miles east of Perenjori, where eucalypts, chiefly sand York gum (*Eucalyptus Lucasi*) and giant mallee (*Eucalyptus oleosa*) and belts of cypress pine (*Callitris glauca*) alternate with mulga.

The soils are chiefly red sands and sandy loams related to the mulga types and a siliceous hard-pan is commonly encountered within 18 inches or two feet of the surface. In spite of the low rainfall, the soils are commonly acidic in reaction and lime accumulation, common in the low rainfall wheatbelt country, is not general.

The rainfall is light and variable. The average, 1929-39, was 11.85 inches of which 7.84 inches fell in the May-October, or growing period.

Wongan Hills Research Station (*Established* 1923).

Wongan Hills lies in the north central portion of the wheatbelt and is about 120 miles north-east of Perth. It is located on a stretch of rolling, heath country. The soils are sandy and gravelly in nature and granite occurs at shallow depths in parts. A gravelly clay subsoil is common over much of the area.

The rainfall, 1926-1942, averaged 14.29 inches of which 10.60 inches fell in the May-October, or growing period.

This locality is representative of a huge area of light land occurring throughout the wheatbelt of Western Australia and farming operations on the station have been very successful. It does not include the poorest types popularly known as "wodjil."

Merredin Research Station (*Established* 1904).

The Merredin Research Station is representative of the heavy brown and red brown solonised soils of the central wheatbelt. It lies in a broad valley running between Merredin and Nangeenan on the Eastern Goldfields railway line. In the virgin state the vegetation consisted chiefly of gimlet (*Eucalyptus salubris*) and salmon gum (*E. salmonophloia*) with a sprinkling of mallee, including *Eucalyptus gracilis*. On the northern and southern boundaries, areas of light land occur, but these have not been used to any extent for farming purposes.

*"Mulga" includes a variety of Acacia scrubs of the low rainfall areas of the State.

The soils consist generally of red brown loams and clay loams with a calcareous, sandy clay subsoil, typical of salmon gum and gimlet woodlands of the wheatbelt. Small patches of brown morrel (*Eucalyptus longicornis*) soils occur.

The rainfall, 1912-42, averaged 11.93 inches of which 8.07 inches fell in the May-October, or growing, period.

The soils are of good quality and highly productive when the rainfall is favourable. The station has a high reputation for wheat and sheep raising.

Yilgarn Research Station (*Established* 1926, *closed* 1940).

The Yilgarn Research Station lies about eight miles east of Southern Cross and, at the time of establishment in 1926, was on the outer fringe of the wheatbelt. This area is now regarded as sub-marginal for wheatgrowing and the station was closed in 1940.

The station embraces a wide range of country including heavy salmon gum woodland, giant mallee (*Eucalyptus oleosa* var. *transcontinentalis*) formations, snuffy morrel and sandplain, or heath, soils. The experiments with which this paper are concerned were located on medium soils of salmon gum and mallee vegetation associations. They ranged from brown sands to sandy loams with calcareous sandy clay subsoils.

The rainfall, 1928-39, averaged 10.52 inches of which 6.57 inches fell in the May-October, or growing, period.

Salmon Gums Research Station (*Established* 1926).

The Salmon Gums Research Station lies in a belt of mallee country in the outlying, south-eastern portion of the wheatbelt. The range of soils includes grey calcareous types, popularly known as "kopi," heavy clay soils, and sandy surface soils with a calcareous sandy clay subsoil. The rate of superphosphate experiment has been located on the sandy surface soils which are the most reliable of the district for wheat growing.

The rainfall, 1926-1942, averaged 13.62 inches of which 7.86 inches fell in the May-October, or growing, period.

The rainfall of the district is generally regarded as somewhat unreliable—much of it falls in the form of light showers and the spread is greater than in most other parts of the wheatbelt.

The district is considered to be suitable for stock raising with wheat growing only on the more satisfactory soil types.

C. PHOSPHATE ABSORPTION BY THE WHEAT CROP.

While the fertiliser requirement of a crop are not simply related to the amount actually absorbed by the crop from the soil, owing to the complex interactions between the soil and the fertiliser, it is of interest to consider the amounts taken up by the wheat crop under Western Australian conditions.

Western Australian wheats (grain and straw) are significantly lower in phosphate than the published standards for overseas crops. Snook (1939) shows that Western Australian wheat grain averages 0.55 per cent. P_2O_5, a figure much lower than European and American standards which are of the order of magnitude of 0.85 per cent. P_2O_5. The straw, too, is exceedingly low in phosphate. Underwood (private communication) has found Western Australian straw to average about 0.08 per cent. P_2O_5. This is exceedingly low in comparison with English analyses of about 0.4 per cent. P_2O_5.

The reason for this low phosphate content of Western Australia wheats is probably related to the low content of readily available phosphate in our soils. The superphosphate application in the rows with the seed gives a large supply of quickly available phosphate in the early growth stages when it is absorbed very rapidly by the young plant. As the season advances the soil renders the water soluble fraction relatively insoluble and slowly available so that the plant is only able to obtain further supplies at a greatly reduced rate. On this account the phosphate absorbed in the early growth stage has to meet the main requirements of the plant and under these conditions it is known that the phosphate content may be very low although the amount of growth is not impaired. Apparently the phosphate absorbed early is used most efficiently in plant metabolism,* but the grazing animal may be denied normal phosphate supplies.

Owing to the low phosphate content of our wheats the drain on the soils is less than would be judged by the usual standards. A 20-bushel crop would contain 5.9 lbs. of phosphoric acid (P_2O_5) in the grain and from 1.3 to 1.9 lbs. in the straw, depending on the grain: straw ratio. Thus, there would be a total of 7.2 to 7.8 lbs. of P_2O_5 in the above-ground portions of a 20-bushel crop. This is equal to 33-35 lbs. of 22 per cent. superphosphate or 40-43 lbs. of 18 per cent. superphosphate now available† (see footnote).

D. SUPERPHOSPHATE REQUIREMENTS.

The main questions with respect to superphosphate applications for wheat crops in Western Australia are:—

1. What is the most economical dressing of superphosphate to apply?
2. What is the residual value of superphosphate not actually absorbed by the crop?
3. What will be the effect of reducing the rate of application of superphosphate on the yield of wheat?

1. What is the most economical dressing of superphosphate to apply?

The most economical dressing of superphosphate will depend on the soil type, the climate, the seasonal conditions, the yield of the crop, the price of wheat, the price and grade of superphosphate, and the quantity of superphosphate previously applied.

Soil type, climate and seasonal conditions are covered by conducting experiments over a number of years on a number of representative farms.

As the prices of the commodities are not fixed the effect of these factors can only be stated in principle.

(a) As the price of wheat increases the optimal‡ application of superphosphate increases.

(b) As the price of the fertiliser increases the optimal application decreases.

The converse will also be true.

Experiments with varying rates of superphosphate on the wheat crop have been carried out on the Research Stations for many years. The main series was started in 1929, but prior to that experiments had been conducted over a number

*Metabolism is a general term referring to the chemical changes which take place during growth and maturation of the plant.

†It is of interest that the phosphorus in a 70-lbs. fat lamb (live weight) is equivalent to 3.6 lbs. of 22 per cent superphosphate; in a 10 cwt. fat bullock to 92 lbs.; and in 1,000 gallons of milk to 97 lbs.

‡The optimal dressing is defined as that which gives the greatest profit per acre. See figures 1 and 2.

of years on the Chapman, Merredin, and Wongan Hills Research Stations. During this period the grade of superphosphate used has varied as follows:—

Period.	Phosphoric Acid (Percentage P_2O_5) Water Soluble.	Total.
1910–1915	17·0	20·0
1915–1916	17·0	17·0
1916–1923	17·0	18·0
1923–1937	20·5	22·0
1937–1941	21·25	23·0
1941–1942	20·25	22·0
1st November, 1942	14·0	18·0

The average price has been £4 12s. 6d. per ton, cash at works.

RESULTS OF THE EXPERIMENTS.

(a) *The Early Experiments.*

The earliest records available show that various experiments to determine the most economical rates of fertiliser application have been conducted since the establishment of the stations. Unfortunately much of these data has been lost, but the results of a number of experiments are of value. In general, these support the findings of the present experiments.

The results of the experiments prior to 1929 are summarised in Table 1. In addition to figures for the research stations, data from the Narrogin School of Agriculture for 1905-1906 are included for sake of interest.

TABLE 1.

RESULTS OF RATE OF SUPERPHOSPHATE EXPERIMENTS WITH WHEAT CARRIED OUT ON AGRICULTURAL RESEARCH STATIONS PRIOR TO 1929. RESULTS EXPRESSED AS BUSHELS PER ACRE AND AS PERCENTAGE OF THE CONTROL.

Research Station.	Period.	No. of Crops.	Estimated Prior Applications of Superphosphate.	Rate of Superphosphate per Acre. Nil.		56 lbs.		112 lbs. (Control)	
			lbs. per acre.	bus. per acre.	%	bus. per acre.	%	bus. per acre.	%
Narrogin School of Agriculture	1905–1906	2	Unknown (possibly 112)	8·0	66	8·9	73	12·2	100
Chapman ...	1915–1917	3	700	11·2	92	11·8	97	12·2	100
Merredin ...	1915–1917	3	320	14·6	76	18·0	94	19·2	100
				75 lbs.		150 lbs. (Control)		225 lbs.	
Chapman ...	1923–1928	6	Paddock— 6A–540 19–720 21–320	15·9	91	17·5	100	18·5	106
Merredin ...	1923–1928	6	Paddock— 3–580 5–710 8–570	24·0	91	26·4	100	27·7	105
Wongan Hills...	1925–1928	4	None ...	13·0	71	18·2	100	19·2	105

The results of a number of experiments on private farms are given in Table 2.

TABLE 2.

RATE OF SUPERPHOSPHATE EXPERIMENTS ON FARMERS' PROPERTIES.

Average of two Plots.

Year.	Place.	Rainfall.		Rate of Superphosphate per acre.					
				75 lbs.		150 lbs.		225 lbs.	
		Growing Period.	Total.	Yield. Bushels per Acre.	%	Yield. (control) Bushels per Acre.	%	Yield Bushels per Acre.	%
1928	Pingrup, Solly Bros., light loam	1,099	1,410	25·8	93	27·7	100	28·0 (one plot only)	101
1928	North Kununoppin, A. E. Hughes, friable loam	668	*	15·0	88	17·0	100	15·8 Considerable variations due to hard patches	93
1930	Pingrup, O. C. Tranter, 4th crop clay loam	1,106	1,578	16·8	90	18·6	100	18·6	100
1930	Kondinin, W. Trembath, red morrel soil	1,075	1,439	29·3	92	32·0	100	31·5	98
1933	Gnowangerup, R. M. Watterson, light land of apparently low fertility	1,158	1,500	9·6	84	10·7	100	11·0	97

* Not available.

For references to Farmers' Trials, see *Jour. Agric., West. Aust.*, as follows :—

1928—Pingrup: Vol. 6, March, 1929, page 128.
1928—North Kununoppin: Vol. 6, March, 1929, page 178.
1930—Pingrup: Vol. 8, June, 1931, page 202.
1930—Kondinin: Vol. 8, March, 1931, page 154.
1933—Gnowangerup: Vol. 11, March, 1934, page 51.

(b) *The Present Experiments.*

The current series of experiments was organised in 1928 and first planted in 1929. These resembled the 1923-1928 experiments, but were designed to include plots receiving no superphosphate each year and a higher application. Rates of superphosphate under test were none, 75, 150, 225, and 300 lbs. per acre.

For convenience in the field, the experiment was divided into two groups, each of three treatments, using 150 lbs. of superphosphate per acre as the common control. One group, the low phosphate group, consisted of no superphosphate, 75 lbs. and 150 lbs. of superphosphate per acre. The high superphosphate group consisted of applications of 150, 225, and 300 lbs. per acre. Treatments were

TABLE 3.

1929 SERIES—AVERAGE YIELDS OF WHEAT GRAIN IN BUSHELS PER ACRE FROM PLOTS RECEIVING SUPERPHOSPHATE AT VARIOUS RATES PER ACRE. EACH PLOT HAS CONSISTENTLY RECEIVED THE SAME SUPERPHOSPHATE TREATMENT SINCE THE COMMENCEMENT OF THE EXPERIMENTS IN 1929. TO FACILITATE THE COMPARISONS EACH YIELD IS ALSO EXPRESSED AS A PERCENTAGE OF THE CONTROL DRESSING OF 150 LBS. OF SUPERPHOSPHATE PER ACRE.

Station.	Period.	No. of Crops Considered.	No Superphosphate.		75 lbs. per Acre.		150 lbs. per Acre. (Control)	225 lbs. per Acre.		300 lbs. per Acre.	
			Bushels per Acre.	Percentage of Control.	Bushels per Acre.	Percentage of Control.	Bushels per Acre.	Bushels per Acre.	Percentage of Control.	Bushels per Acre.	Percentage of Control.
A. Chapman	1929–42	14	11·6	82	13·5	96	14·1	14·2	101	14·5	104
B Dampawah ...	1929–39	10	6·6	45	13·6	92	14·8	15·0	101	15·1	102
C. Wongan Hills† ...	1929–42	13	4·2	20	16·5	82	20·5	21·1	103	21·3	104
D. Merredin*	1929–42	12	13·1	60	20·2	93	21·8	22·4	103	2·7	104
E. Yilgarn	1929–39	10	8·9	55	13·8	85	16·2	16·4	101	16·4	101
F. Salmon Gums ...	1929–42	14	6·9	47	13·1	89	14·8	15·4	104	15·6	105

* No harvest 1940 owing to complete crop failure under drought conditions. Harvester yields incomplete in 1939 owing to severe lodging. Data discarded. † 1937 crops destroyed by hail.

replicated five times, but were not randomised, so statistical treatment has not been applied. Of course, the control plots have not yielded exactly the same in each group, but on the average the yields have been very similar.

A summary of the results from the experiments on each station is given in Table 3. To make the comparison simple, in Table 3 the actual average yields are given for the low phosphate group but, for the heavy phosphate group, the control yield is adjusted to equal that of the control in the low phosphate group and the same percentage adjustment applied to the yields from the other treatments.

The actual yields are given in detail in the appendix, Tables A, B, C, D, E, and F.

The results show increasing yield with increasing superphosphate application up to 300 lbs. per acre, the maximum dressing used, but the differences above 150 lbs. of superphosphate per acre are too small to be of practical significance as far as the wheat yield is concerned.

The important consideration is the financial return from the fertiliser used. The rate per acre which will give the maximum nett monetary return per acre is most desirable for the farmer, and is known as the optimal dressing. This may be arrived at by deducting from the value of the total yield for each treatment the total cost involved.

In this paper it is assumed that:—

(a) The value of the wheat on the farm after deducting handling and marketing charges is 3s. 4d. per bushel.

(b) The cost of superphosphate on the farm is £5 per ton.

(c) the operational and administrative costs per acre do not vary with the yield.

This leaves the cost of the superphosphate as the only variable and the nett value of the wheat grown on an acre will, therefore, be obtained by deducting the cost of the fertiliser used. On the basis of these assumptions the graphs in figure 1 have been constructed, and show the results for Chapman, Wongan Hills, and Merredin. The highest point of the nett value graph gives the optimal dressings. For 22 per cent. superphosphate these are of the order of magnitude of:—

Chapman Research Station	80 lbs. per acre.
Wongan Hills Research Station ..	130 lbs. per acre.
Merredin Research Station	110 lbs. per acre.

By a similar procedure the optimal dressings for the other research stations are:—

Dampawah Research Station	100 lbs. per acre.
Yilgarn Research Station	130 lbs. per acre.
Salmon Gums Research Station ..	110 lbs. per acre.

Somewhat lower figures for optimal dressings of superphosphate were obtained from experiments commenced in 1941 and 1942. (Figure 2.) These were as follows:—

Chapman	No response to superphosphate—weed competition very severe.
Wongan Hills	85 lbs. per acre.
Merredin	60 lbs. per acre.
Salmon Gums	80 lbs. per acre.

This shows that the superphosphate applied since 1929 has improved the phosphate status of the soils and indicates that the optimal rates tend to decline as the total amount of superphosphate previously applied increases.

The elimination of superphosphate on new land on the research stations has given greatly reduced yields, even disastrous results. At Chapman and Wongan Hills, on light land not previously cropped, a complete failure resulted from withholding superphosphate. On stronger soil types such as at Salmon Gums, Dampawah, and Yilgarn, the reduction was about 50 per cent. That similar results would have been obtained at Merredin is indicated by the report of Clifton (1905), p. 458, concerning the first crop sown on the station in 1905. "One hundred and five pounds of superphosphate per acre was used as a fertiliser, but here and there throughout the crop a small strip has been left for comparative purposes. The difference between the crop of these strips and the fertilised land adjoining, otherwise dealt with in exactly the same manner, is as might be expected, very marked."

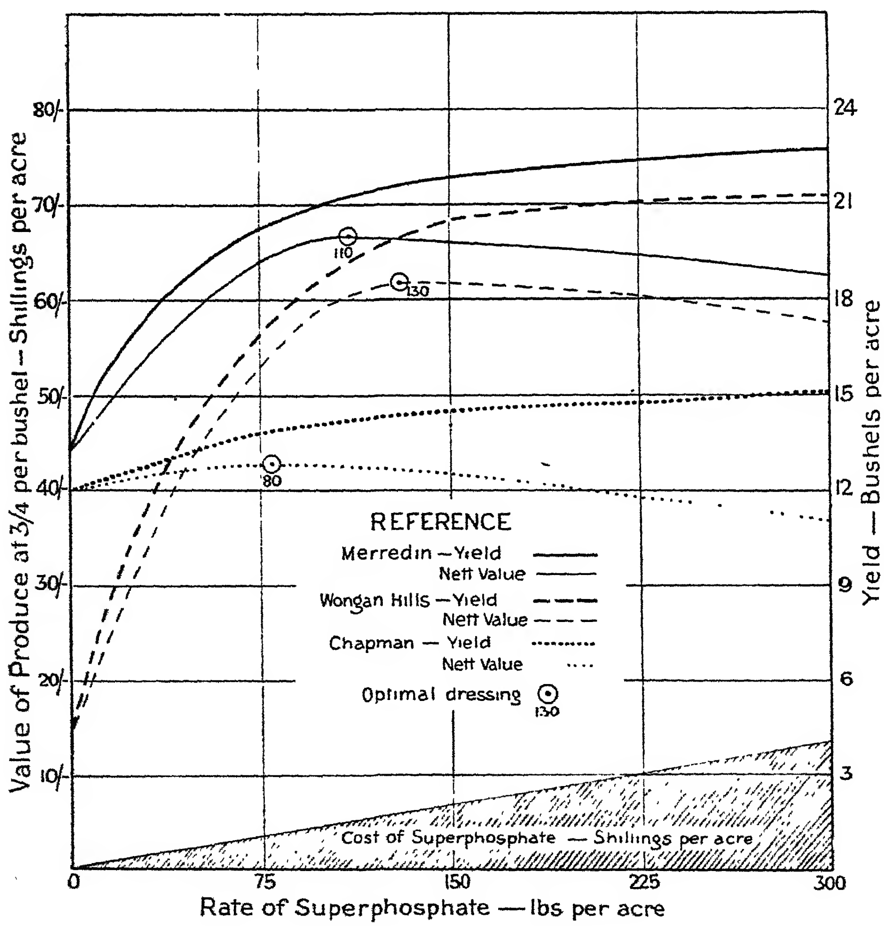

Fig. 1.

Effect of various rates of superphosphate on the yield of wheat and the net monetary return per acre. 1929 series.

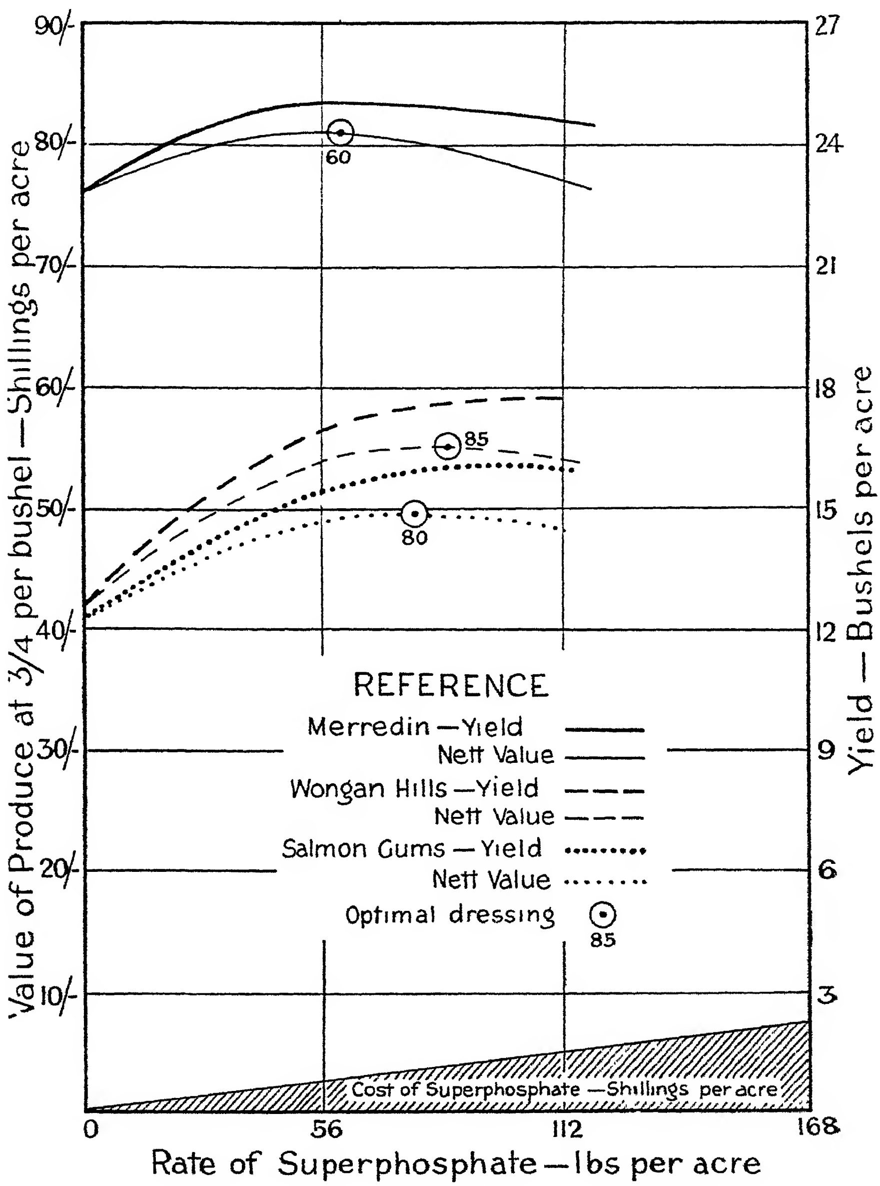

Fig. 2.

Effect of various rates of superphosphate on the yield of wheat and the net monetary return per acre. 1941 series.

On heavy soil types of the Merredin Research Station, which had carried several previous crops well fertilised with superphosphate, the reduction in yield of wheat with no fertiliser as compared with the crop receiving 150 lbs. of superphosphate per acre averaged 40 per cent. Least reduction in yield, 20 per cent., was observed on the Chapman Research Station. These soils would have received somewhat larger prior applications of superphosphate than on the Merredin Station. (See Tables 4, 5, 6, and 7 and A-F of Appendix.)

YIELDS OF SUCCESSIVE WHEAT CROPS GROWN ON THE SAME PLOTS WITHOUT SUPERPHOSPHATE.

Year.	Rate of Superphosphate Application (lbs. per Acre).			No Superphosphate as Percentage of :	
	None.	75.	150.	75 lbs.	150 lbs.
	bush. per acre.	bush. per acre.	bush. per acre.	%	%
Table 4.—CHAPMAN RESEARCH STATION, 1929-1942.					
PADDOCK 21 (cleared 1914)—					
Six previous crops—total superphosphate, 500 lbs. per acre.					
1929	8·1	9·7	11·3	84	72
1932	7·0	9·4	11·0	74	64
1934	5·6	6·6	7·4	85	76
1936	14·7	15·2	15·1	97	97
1941	11·8	12·1	13·6	98	87
PADDOCK 19—					
Eight crops since 1911—total superphosphate, 626 lbs. per acre.					
Known prior crops in 1903, 1904, 1906, etc., received a total of 300 lbs. of superphosphate.					
1930	13·1	13·4	13·6	98	96
1933	10·4	11·6	11·8	90	88
1938	12·4	15·8	14·9	78	83
1940	15·6	19·8	20·1	79	78
1942	8·9	9·0	8·5	99	105
PADDOCK 6A—					
Seven crops since 1910—total superphosphate, 632 lbs. per acre.					
Known prior crop in 1904 received 112 lbs. of superphosphate per acre.					
1931	13·7	17·6	19·8	78	69
1935	13·7	17·3	19·3	79	71
1937	11·6	12·5	12·8	93	91
1939	16·4	18·5	18·0	89	91
Table 5.—WONGAN HILLS RESEARCH STATION, 1929-1942.					
PADDOCK 1E—					
Cropped 1926 and 1928—total superphosphate, 262 lbs. per acre.					
1932	12·6	20·8	22·7	61	56
1934	9·3	22·4	25·1	42	37
1937		crop destroyed by hail			
1941	12·2	24·4	25·9	50	47
PADDOCK 4H—					
Cropped 1930—total superphosphate, 150 lbs. per acre.					
1938	7·8	21·3	25·6	37	30
1942	7·1	21·6	23·2	33	31
PADDOCK 2E—					
No previous crops or fertiliser applications.					
1929	*Nil*	5·9	8·7	...	...
1931	*Nil*	10·6	15·8	...	...
1935	*Nil*	17·5	25·0	...	...
1939	1·3	10·6	14·2	12	9
PADDOCK 3E—					
No previous crops or fertiliser applications.					
1930	*Nil*	12·5	15·2	...	...
1933	*Nil*	11·9	16·8	...	...
1936	*Nil*	19·8	24·0	...	...
1940	3·8	20·8	24·9	18	15

YIELDS OF SUCCESSIVE WHEAT CROPS GROWN ON THE SAME PLOTS WITHOUT SUPERPHOSPHATE—*continued.*

Table 6.—MERREDIN RESEARCH STATION, 1929-1942.

PADDOCK 3—

Six crops, 1911–1928—total superphosphate, 524 lbs. per acre.
Known prior crops in 1906, 1908, probably received total of 150 lbs. of superphosphate per acre.

Year.	Rate of Superphosphate Application (lbs. per Acre). None.	75.	150.	No Superphosphate as Percentage of: 75 lbs.	150 lbs.
	bush. per acre.	bush. per acre.	bush. per acre.	%	%
1929	20·0	25·1	27·2	80	74
1932	10·7	22·9	25·4	47	42
1934	13·2	21·9	25·0	60	53
1936	3·2	5·7	5·7	56	56
1938	7·6	12·2	13·3	62	57
1940	...	No crop account drought		...	...

PADDOCK 5—

Six crops, 1911–1928—total superphosphate applied, 612 lbs. per acre.
Known prior crop in 1910 received 112 lbs. of superphosphate per acre.

Year.	None.	75.	150.	75 lbs.	150 lbs.
1931	19·5	26·9	27·4	72	71
1933	13·4	18·9	21·7	71	62
1935	6·6	11·1	12·9	59	51
1942	21·6	25·6	26·7	84	81

PADDOCK 8—

Seven crops, 1911–1928—total superphosphate applied, 492 lbs. per acre.
Probably a prior crop in 1909 which would have received 1 cwt. of superphosphate per acre.

Year.	None.	75.	150.	75 lbs.	150 lbs.
1930	12·9	25·2	28·1	51	46
1937	8·4	14·0	14·3	60	59
1939	...	lodging upset	results	...	...
1941	19·9	33·0	33·8	60	59

Table 7.—SALMON GUMS RESEARCH STATION, 1929-1942.

PADDOCK A1—

Cropped 1927—total superphosphate applied, 90 lbs. per acre.

Year.	None.	75.	150.	75 lbs.	150 lbs.
1929	5·0	14·4	15·6	35	32
1931	8·3	15·6	15·6	53	53
1933	5·5	13·0	18·0	42	31
1935	11·4	13·0	15·3	88	75
1937	9·6	13·3	15·5	72	62
1939	8·6	14·7	17·8	59	48

PADDOCK A3—

Cropped 1927, 1929, and 1931—total superphosphate applied, 290 lbs. per acre.

Year.	None.	75.	150.	75 lbs.	150 lbs.
1936	3·9	7·2	8·8	54	44
1938	9·5	18·4	17·7	52	54
1940	2·0	2·8	3·2	71	62
1942	8·8	14·6	17·0	60	52

PADDOCK B1—

Cropped 1928—total superphosphate applied, 90 lbs. per acre.

Year.	None.	75.	150.	75 lbs.	150 lbs.
1930	8·2	12·7	13·9	65	59
1932	7·3	22·9	24·2	32	30
1934	2·8	9·4	12·5	30	22
1941*	5·8	11·2	12·5	52	46

* Four plots only.

It may be concluded that there is no need to use more than 150 lbs. of 22 per cent. superphosphate for maximum wheat returns on Western Australian soils. In fact, on the forest and mallee soils it is probable that a dressing of the order of magnitude of 1 cwt. per acre is adequate. Up to 150 lbs. per acre may prove profitable on the light soil types. Where the land has been well farmed and fertilised for many years these rates could be considerably reduced.

If more is applied the superphosphate is not wasted. It is not washed out by the rains as nitrate of soda would be, but is absorbed by the soil to build up reserves which are slowly available. These are of great value for subsequent cereal and pasture crops, particularly if a small amount of superphosphate is applied at seeding, for sown crops, or in the autumn for pastures.

2. What is the residual value of the superphosphate not actually absorbed by the crop?

From the information derived from the examination of Western Australian material, it is apparent that only a fraction of the superphosphate applied with the crop is actually absorbed by the growing plants. A 20-bushel wheat crop will take up the equivalent of one-third of the phosphate applied in a dressing of 100 lbs. of 22 per cent. superphosphate per acre. The remainder is absorbed by the soil.

Soils have a remarkable capacity for absorbing water soluble phosphate and it is only under exceptional conditions that losses occur through the leaching action of water. The bulk of the superphosphate not absorbed by the crop remains in the surface soil. Only when the surface soil is removed by erosion is there a loss of the phosphate.

The capacity of a soil to absorb phosphate may be likened to the soaking up of water by a sponge. A sponge will take up water until the pores are full—when it is saturated. As the sponge approaches saturation the water becomes increasingly easy to remove by squeezing. With respect to the soil the amount of phosphate needed for saturation will depend on its properties, particularly the nature of the clay fraction, the organic matter, the lime content, the amount of iron, aluminium and similar oxides, etc. As saturation is approached the phosphate becomes more loosely held and thus more readily available to the crop.

In many parts of the world, some soils are sufficiently saturated naturally for most crops to obtain adequate supplies of available phosphate without the addition of phosphatic fertilisers. Others will not grow certain crops unless well fertilised with superphosphate. Unfortunately, most Western Australian soils are, in the virgin state, very poorly supplied with available phosphate and crops need superphosphate from the very outset for maximum production, to enable the plant to take up its initial needs before the soil has completely absorbed the fertiliser and rendered it slowly available.

There is little evidence regarding the amounts of superphosphate required to saturate the various wheat soils of Western Australia. It is known, however, that more is needed for the ironstone gravel soils such as occur at Wongan Hills than on the timber and mallee types represented by the other stations.

These latter types seem to show small response, probably about 10 per cent. increase in yield, to superphosphate when about half a ton of superphosphate per acre has been applied with previous crops. Some South Australian soils are reported to require about 15 cwts. of superphosphate per acre before the crop

is able to satisfy its phosphate needs without fertilisation. The heavy red loams of northern New South Wales appear able to absorb as much as 90 tons of superphosphate per acre foot of soil.

With soils of moderate phosphate absorption capacity it is desirable to meet the phosphate requirements as soon as possible by liberal fertiliser applications. This amounts to building up capital reserves. Yield reductions with wheat crops sown with small amounts of, or even without superphosphate in cases of necessity, are generally small where the land has received liberal amounts with previous crops.

The yield reductions of series of crops sown without superphosphate on land which had received superphosphate with a number of previous crops are shown in Tables 4, 5, 6, and 7.

Of these, the figures for Wongan Hills (Table 5) are most interesting and important as on this station the yield of wheat on virgin land without superphosphate is nil. On virgin land in paddocks 2E and 3E, no crop was obtained from the first three sowings in each case, but movement of the phosphate-treated soil from adjacent plots permitted a slight production of wheat in the fourth season. By contrast, on land in paddock 1E, which had received 262 lbs. of superphosphate per acre, and in paddock 4H, 150 lbs. per acre, prior to the commencement of the experiment the average yields were 11.4 and 7.4 bushels per acre, respectively. Of course, these yields are not high, but are not the complete failures which are obtained on virgin land of this type.

To determine the effect of sowing wheat without superphosphate and with small dressings (56 and 112 lbs. per acre) on land which had received considerably more superphosphate as a result of cropping subsequent to 1928, a further series of experiments was commenced on the Chapman, Wongan Hills, Merredin, and Salmon Gums Research Stations in 1941. The results are given in detail in Table 8. The optimal applications are indicated in figure 2.

These results show a substantial increase in the relative yield of wheat on the plots receiving no superphosphate, as compared with the 1929 series of experiments. This increase is undoubtedly due to the larger superphosphate residues accumulated since 1928. Table 9 illustrates this increased residual value.

The 1941 series figures are calculated to 75 lbs. of superphosphate per acre from the data for 56 and 112 lbs. per acre, as illustrated in figure 2. In the 1929 series only the data for the first crops without superphosphate are used.

This increased residual value of higher dressings of superphosphate is illustrated by an experiment conducted in 1915-1921 at the Merredin Research Station. (See Table 1.) In 1921 the experimental area was sown with no superphosphate, and the yields after the different treatments compared.

Prior to the commencement of this experiment the land had received 320 lbs. of superphosphate per acre. In 1921, the yield on the plots which had received no superphosphate with the 1915, 1917, and 1919 crops was 20.6 bushels per acre, 90 per cent. of the yields with no superphosphate on the plots dressed in 1915, 1917, 1919 with 1 cwt. per acre. The plots receiving 56 lbs. per acre in this period and none in 1921 yielded 96 per cent. of those which had received the hundredweight.

Maintenance of Yields on Plots receiving no Superphosphate.

The yields on the plots receiving no superphosphate have been well maintained for a number of crops since the inception of the rate of superphosphate experi-

TABLE 8.

1941 SERIES—YIELDS OF WHEAT SOWN ON OLD LAND WITHOUT SUPERPHOSPHATE AT THE RESEARCH STATIONS IN COMPARISON WITH DRESSINGS OF 56 AND 112 LBS. PER ACRE.

Research Station.	Year.	Paddock.	Superphosphate Applications since 1928.	Estimated Total previous Superphosphate Applications.	Rate of Superphosphate applied (lbs. per acre).				
					Nil.		56 lbs.		112 lbs. (Control)
					Bushels per Acre.	Percentage of Control.	Bushels per Acre.	Percentage of Control.	Bushels per Acre.
			lbs. per acre.	lbs. per acre.					
Chapman	1942	19	448	1,374	14·2	104	14·0	103	13·6
Wongan Hills	1941	1E	485	747	13·0	75	16·4	95	17·3
	1942	4H	270	270	12·0	65	17·4	95	18·2
	Average	...	...	...	12·5	70	16·9	95	17·7
Merredin	1941	8	374	978	26·9	96	28·8	103	28·1
	1942	5	336	1,060	24·6	90	27·7	101	27·4
	1942	3	672	1,346	16·8	91	18 4	100	18·4
	Average	...	...	...	22·8	93	25·0	101	24·6
Salmon Gums	1942	A3	448	738	12·2	77	15·4	97	16·0

TABLE 9.

ESTIMATED RELATIVE YIELDS OF WHEAT ON PLOTS RECEIVING NO SUPERPHOSPHATE FOR THE FIRST TIME IN THE 1929 SERIES AS COMPARED WITH THE 1941 SERIES. YIELDS ON PLOTS RECEIVING 75 LBS. OF SUPERPHOSPHATE PER ACRE ARE ADOPTED AS CONTROLS.

Research Station.	Paddock.	Superphosphate Applications.		Percentage Yields on "no Superphosphate" Plots as compared with 75 lbs per acre Plots.			
		Additional since commencement of 1929 Series.	Estimated Total prior to commencement of 1941 Series.	1929 Series.		1941 Series.	
				Year.	%	Year.	%
		lbs. per acre.	lbs. per acre.				
Chapman	6A	448	1,192	1931	78	...	..
	19	448	1,374	1930	98	1942	102
	21	560	1,060	1929	84	..	...
	Average	...	...	...	87	...	102
Wongan Hills	1E	485	747	1932	61	1941	77
	4H	120*	270	1938	37	1942	67
	Average	...	...	...	49	...	72
Merredin	3	672	1,350	1929	80	1942	90
	5	336	1,060	1931	72	1942	88
	8	374	970	1930	51	1941	92
	Average	...	...	...	68	...	90
Salmon Gums	A1	672	762	1929	35	...	...
	A3	448	738	1936	54	1942	78
	B1	448	538	1930	65	...	...
	Average	...	...	...	51	...	78

* In 1938, which was the first year of the 1929 Series in this paddock. No subsequent additions were made.

ments in 1929. The data in Tables 4, 5, 6, and 7, show no evidence of deterioration in percentage yield even after as many as six crops. Just how many crops, yielding about 50 per cent. of the fertilised plots, may be carried can only be determined by continued experimentation.

It is known that such factors as the manurial action of grazing stock and soil movement due to cultivation and wind action do contribute to the maintenance of yields on the unfertilised plots which lie adjacent to well-fertilised areas. This is established by observations at Wongan Hills on the no superphosphate plots in paddocks 2E and 3E which had not received superphosphate prior to the initiation of the experiment. For three crops there was no harvestable crop on these plots, but in the course of time the edges adjacent to the fertilised plots made more growth than the centres. The fourth crop, planted ten years later in each case, showed a small but definite yield. Plots on 2E yielded 1.3 bushels (9 per cent. of the 150 lbs. per acre plots) and on 3E, 3.8 bushels (15 per cent.). At Merredin the no fertiliser plots still stand out uniformly at flowering time owing to slightly delayed maturity, although yield differences are small (7 per cent.) in the case of the 1941 series. It is considered that the addition of phosphate by the above factors to the no superphosphate plots is real but not substantial and does not invalidate the conclusions drawn from these data.

3. What will be the effect of reducing the rate of application of superphosphate on the yield of wheat?

As the rate of application of superphosphate is reduced below the optimal levels indicated by the experiments discussed above, the yield of wheat will be reduced. On old, well fertilised land the reduction in the first crop will be small. Complete elimination of superphosphate under experimental conditions has effected a loss ranging from 25 to 35 per cent. on light land and from nil to 25 per cent. on medium and heavy land.

The reduction with applications of 40 lbs. of 18 per cent. superphosphate is not likely to exceed 25 per cent. except on relatively new land and very light soils, and on the medium and stronger soil types yields will probably exceed 90 per cent. of the optimal dressing, as least for the first crop or two. Crop failure due to such a small application of superphosphate need not be feared

The phosphate needs of a 20-bushel crop of wheat will be just met by 40 lbs. of the 18 per cent. superphosphate being marketed. There will be no residual amount which would be valuable for succeeding pastures. Where these pastures are improved types such as subterranean clover and burr trefoil an annual top-dressing with the superphosphate, if procurable for the purpose, should be practised.

E.—THE USE OF THE SUPERPHOSPHATE RATION.

The superphosphate supply should be spread over the whole acreage for which the ration is granted. It should not be concentrated on a portion of the area being sown or for which topdressing has been allowed.

Of course, this will involve certain extra costs and the return *per acre* actually dressed with the reduced rate of application of superphosphate will be less; but more food will be produced for each ton of superphosphate and from each farm. Quantity of production, especially of grassland products, is vitally important at present.

It is well established that the greatest crop response is obtained from the first fraction of a fertiliser application. That is, the first 40 lbs. of superphosphate will give a greater yield increase than will the second 40 lbs. if the application is brought up to 80 lbs. per acre for a comparison. This observation has been embodied in the Law of Diminishing Returns which is the basis for any programme of fertiliser rationing.

A quantity of readily available or water soluble phosphate is of prime importance to the seedling to promote rapid early growth and root development. In consequence, superphosphate should be applied at seeding time to ensure a vigorous start and an extensive root system which will be able to make utmost use of the slowly available phosphate in the soil. It has been shown under experimental conditions that wheat, generously supplied with available phosphate in the first four to six weeks of its growth, may absorb sufficient phosphate to produce a heavy crop without access to any further supply. Under these conditions the phosphate content of the plant is exceptionally low without impairment of the growth. The low phosphate content of Western Australian wheats and straws indicates that the plants probably enjoy a luxury phosphate level for a short period, but the rate of intake in the later growth stages is greatly restricted owing to the rapid absorption of the water soluble phosphate by the soil.

This supply of water soluble phosphate for the wheat seedling is important to promote early maturity. Even where little difference in yield between unfertilised plots and those receiving superphosphate is observed at harvest, the quicker growth with readily available phosphate is quite marked during the growing period. Even a few days advantage in maturity may be important in the avoidance of certain diseases or dry spring conditions common in Western Australia.

An experiment carried out on the research stations in the period 1928-1931, showed a yield advantage in favour of superphosphate application at seeding. Adopting a total application of 225 lbs. of superphosphate per acre in the 1928-31 series, some or all was applied in March and the remainder, if any, at seeding. The yields are given in Table 10.

A somewhat similar experiment was carried out in 1941-42. In July of 1941 an area of fallow in paddock 5 was dressed with superphosphate at the rate of 112 lbs. per acre.

This treatment was deemed to represent the effect of a drought and complete crop failure. In 1942 an experiment was planted with wheat on this area using superphosphate at 56 and 112 lbs. per acre in comparison with no superphosphate. The results were:—

No superphosphate	23.7 bushels per acre (96%).
56 lbs. per acre	23.8 bushels per acre (96%).
112 lbs. per acre (control) ..	24.7 bushels per acre (100%).

It is most likely that these differences are due to experimental error. The land had received a little more than 9 cwts. of superphosphate per acre prior to the July dressing in 1941, and the residual value of these earlier dressings would largely account for the high yields of the no superphosphate plots. It is difficult to differentiate the effect of the July, 1941, application.

F.—DISCUSSION.

Contrary to the belief of many farmers, there is no evidence of danger of crop failure due to lack of superphosphate when wheat is grown without super-

TABLE 10.

EFFECT OF TIME OF APPLICATION OF SUPERPHOSPHATE ON THE YIELD OF WHEAT ON THE AGRICULTURAL RESEARCH STATIONS.

Four Crops,—1928–1931—Total Superphosphate 225 lbs. per Acre with each Crop.

Research Station.	Paddocks Cropped.	Application of Superphosphate.					
		150 lbs. at Seeding. 75 lbs. in March.		75 lbs. at Seeding. 150 lbs. in March.		225 lbs. in March.	
		Yield.	Per cent.	Yield.	Percentage of 150 lbs. at Seeding.	Yield.	Percent ge of 150 lbs. at Seeding.
		bush. per acre.		bush. per acre.		bush. per acre.	
Chapman	6A, 18A, and 19 ...	14·7	100	13·9	95	13·8	94
Dampawah (2 crops)	A and B	14·0	100	13·8	99	13·2	94
Wongan Hills	1E, 2E, 3E	19·1	100	18·2	95	17·0	89
Merredin	3, 5, and 8	25·7	100	25·5	99	24·1	94
Yilgarn	D, E, and C2 ...	17·9	100	16·8	94	16·5	92
Salmon Gums	A1 and B1 ...	14·7	100	14·1	96	13·3	90

PREVIOUS SUPERPHOSPHATE DRESSINGS PER ACRE.

CHAPMAN—6A—Six previous crops since 1911, 520 lbs. of superphosphate; 18A and 19—Eight previous crops since 1911, 18A—702 lbs. of superphosphate; 19—626 lbs. of superphosphate.
DAMPAWAH—None.
WONGAN HILLS—1E—One previous crop, 112 lbs. of superphosphate; 2E and 3E—None.
MERREDIN—3—Six previous crops since 1911, 524 lbs. of superphosphate; 5—Six previous crops since 1910, 612 lbs. of superphosphate; 8—Seven crops since 1911, 492 lbs. of superphosphate.
YILGARN—None.
SALMON GUMS—A1—90 lbs. of superphosphate; B1—None.

phosphate on old well-prepared land, previously well fertilised. Maximum yields are not obtained, but the reduction is small.

When small applications of superphosphate are used the yield reduction will be considerably less.

This is established by the results of numerous experiments carried out during the past forty years under a wide range of conditions representative of the wheat belt. All of this work has been carried out under field conditions using methods similar to those commonly adopted and proved as good farming practice throughout the wheatbelt. In all cases the experimental areas received the same cultural treatments and the only differences involved were the rates of superphosphate applied.

The data presented and discussed in this paper leave little room for doubt.

It may be argued that the small field plots used—one-eighth of an acre in area—although replicated five times for each treatment, are not truly representative of field conditions. This argument is unsound.

Study of the yields of wheat at the Research Stations in 1942, with superphosphate reduced to 60 to 70 lbs. per acre, or approximately two-thirds of the normal, gives no reason to suppose that this reduction has adversely affected the returns. In fact, the yield per inch of rain during the growing period at Merredin, Salmon Gums, and Avondale, has even been somewhat higher in 1942 with a lower rate of superphosphate than in the most recent year for which valid comparison is possible. At Merredin, in 1941, the 74 acres of the variety Bencubbin yielded 27.8 bushels per acre—2.7 bushels per inch of rain during the growing period. In 1942, the 58 acres under the same variety, growing on a similar soil type and planted at the same time, yielded 23.3 bushels per acre—2.8 bushels per inch of rain during the growing period. The growing period rainfall in 1942 was 1.8 inches lower than in 1941. At Salmon Gums the yield of wheat on the farm in 1942 (45 acres) was 20.1 bushels per acre—2.1 bushels per inch of rain in the growing period. The 1940 and 1941 crops practically failed owing to drought conditions, but in 1938 growing conditions were very similar to 1942. In that year the wheat yield on the station was 21.1 bushels per acre—1.9 bushels per inch of rain in the growing period. In 1939, a less favourable season, the production of wheat per inch of rain was 2.0 bushels. At the Avondale Research Station, Beverley, the figures show that the yields of wheat were somewhat higher per acre and per inch of rain in 1942 than in 1941 when the seasonal and cultural conditions were similar.

On the other hand, at Wongan Hills, the yield of wheat in 1942 with a higher rainfall, was somewhat lower than in 1941, 12.9 bushels per acre as compared with 13.9. This is in keeping with the usual experience of an inverse relationship between yield and rainfall on this station. The yield of wheat per inch of growing period rain was 1.05 bushels in 1942 and 1.29 in 1941.

In presenting these figures it must be pointed out that great caution must be exercised in the comparison of crop production in different seasons. These results, however, indicate that no decrease in yield has resulted which can be attributed to the use of reduced dressings of superphosphate in 1942.

Many farmers will raise the question of the effect of reduced superphosphate dressings with the wheat crop on the succeeding pasture. No experimental data are available from these experiments and the matter is, therefore, not discussed. Observations are planned for 1943.

TABLE A.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.

Chapman Research Station.—Rate of Superphosphate Experiment 1929-1942.

Year.	Paddock.	Rainfall Points. Annual.	Rainfall Points. May-Oct.	Low Superphosphate Group. No Superphosphate. bushels	%	75 lbs. per Acre. bushels	%	150 lbs. per Acre. (Control) bushels	%	High Superphosphate Group. 150 lbs. per Acre. (Control) bushels	%	225 lbs. per Acre. bushels	%	300 lbs. per Acre. bushels	%
1929 ...	21	1,783	1,554	8·1	72	9·7	86	11·3	100	13·6	100	15·2	112	15·0	110
1930 ...	19	1,965	1,856	13·1	96	13·4	98	13·6	100	12·0	100	11·9	99	10·9	91
1931 ...	6A	2,009	1,755	13·7	69	17·6	89	19·8	100	18·6	100	19·9	107	20·6	111
1932 ...	21	2,044	1,716	7·0	64	9·4	85	11·0	100	10·7	100	10·2	95	12·1	113
1933 ...	19	2,174	1,883	10·4	88	11·6	98	11·8	100	12·6	100	12·0	95	12·7	101
1934 ...	*21	2,370	1,348	5·6	76	6·6	89	7·4	100	5·2	100	5·9	113	4·7	90
1935 ...	6A	1,405	1,013	13·7	71	17·3	90	19·3	100	16·3	100	15·1	93	15·7	96
1936 ...	21	1,593	1,427	14·7	97	15·2	101	15·1	100	16·2	100	16·8	104	19·2	118
1937 ...	6A	1,561	1,417	11·6	91	12·5	98	12·8	100	11·9	100	13·5	113	13·5	113
1938 ...	19	1,306	939	12·4	83	15·8	106	14·9	100	15·4	100	14·6	95	13·4	87
1939 ...	6A	2,575	2,101	16·4	91	18·5	103	18·0	100	19·4	100	18·8	97	19·4	100
1940 ...	19	1,237	1,132	15·6	78	19·8	99	20·1	100	21·9	100	22·1	101	22·0	100
1941 ...	21	1,802	1,474	11·8	87	12·1	89	13·6	100	12·3	100	12·6	102	13·1	107
1942 ...	†19	1,783	1,527	8·9	105	9·0	106	8·5	100	9·8	100	9·0	92	9·2	94
Average, 14 crops				11·6	82	13·5	96	14·1	100	14·0	100	14·1	101	14·4	103
				s. d.		s. d.		s. d.		s. d.		s. d.		s. d.	
Value of Wheat at 3s. 4d. per bushel ...				38 8		45 0		47 0		46 8		47 0		48 0	
Cost of Superphosphate				...		3 4		6 8		6 8		10 1		13 5	
Net Value of Wheat				38 8		41 8		40 4		40 0		36 11		34 7	

* Severe damage from rust. † Severe damage from weeds, especially with the higher rates of superphosphate.

Superphosphate applications, 1910–1928 period and known previous applications from available data :—

Paddock 21 (cleared 1914).—6 crops, total superphosphate 500 lbs. per acre.

Paddock 19 (cleared 1902).—8 crops, 1911–28 period, total superphosphate 626 lbs. per acre ; 3 known crops, 1903–10 period, total superphosphate 300 lbs. per acre.

Paddock 6A (cleared 1903).—7 crops, 1910–28 period, total superphosphate 632 lbs. per acre ; 1 probable crop, 1903–10 period, total superphosphate 112 lbs. per acre.

TABLE B.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.

Dampawah Research Station—Rate of Superphosphate Experiment—1929-1939.

No superphosphate applications prior to commencement of the experiment.

Year.	Pad-dock.	Rainfall Points.		Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.											
				Low Superphosphate Group.						High Superphosphate Group.					
		Annual.	May-Oct.	No Superphosphate.		75 lbs. per Acre.		150 lbs. per Acre. (Control)		150 lbs. per Acre. (Control)		225 lbs. per Acre.		300 lbs. per Acre.	
				bushels	%	bushels	%	bushels	%	bushels	%	bushels	%	bushels	%
1929 ...	A	1,095	674	7·0	34	18·3	88	20·8	100	21·0	100	20·8	99	21·5	102
1930 ...	B	1,069	768	5·3	65	*10·7	130	8·2	100	6·2	100	5·1	82	†5·1	82
1931 ...	C	1,187	848	6·5	62	10·8	103	10·5	100	9·7	100	9·2	95	9·2	95
1932 ...	A	1,156	920	6·7	37	16·5	90	18·3	100	17·6	100	17·8	101	18·5	105
1933 ...	B	1,655	1,394	13·4	68	17·6	89	19·8	100	19·4	100	20·2	104	20·5	106
1934 ...	C	1,308	672	6·3	28	19·2	86	22·4	100	21·5	100	22·4	104	22·2	103
1935 ...	A	1,212	508	3·8	28	11·2	81	13·8	100	12·8	100	14·0	109	13·6	106
1936 ...	C	940	544	Not harvested for grain owing to frost effects.						Results discarded owing to frost effects.					
1937 ...	A	873	668	5·3	46	10·0	87	11·5	100	10·7	100	10·3	96	10·0	93
1938 ...	C	590	400	*Nil*	...	2·3	82	2·8	100	4·2	100	4·5	107	4·4	105
1939 ...	B	1,952	1,221	12·1	62	19·6	100	19·6	100	16·0	100	16·6	104	17·3	108
Average 10 crops ...	...	...	...	6·6	45	13·6	92	14·8	100	13·9	100	14·1	101	14·2	102
				s. d.		s. d.		s. d.		s. d.		s. d.		s. d.	
Value of Wheat at 3s. 4d. per bushel ...				22 0		45 4		49 4		46 4		47 0		47 4	
Cost of Superphosphate				...		3 4		6 8		6 8		10 1		13 5	
Net Value of Wheat				22 0		42 0		42 8		39 8		36 11		33 11	

* Calculated from result obtained in high superphosphate group. † No yield data. Yield for 225 lbs. of superphosphate per acre assumed to avoid weighting the average in favour of 300 lbs. per acre.

Hay Yields, 1936.—No superphosphate, 0·8 cwts. per acre (6 per cent.); 75 lbs. per acre, 11·7 cwts. per acre (89 per cent.); 150 lbs. per acre 13·1 cwts. per acre (100 per cent.).

TABLE C.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.

Wongan Hills Research Station.—Rate of Superphosphate Experiment—1929-1942.

Year.	Pad-dock.	Rainfall Points.		Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.											
				Low Superphosphate Group.						High Superphosphate Group.					
		Annual.	May-Oct.	No Superphosphate.		75 lbs. per Acre.		150 lbs. per Acre. (Control)		150 lbs. per Acre. (Control)		225 lbs. per Acre.		300 lbs. per Acre.	
				bushels	%	bushels	%	bushels	%	bushels	%	bushels	%	bushels	%
1929 ...	2E	1,541	1,175	*Nil*	...	5·9	68	8·7	100	8·4	100	9·0	107	9·2	110
1930 ...	3E	1,299	1,048	*Nil*	...	12·5	82	15·2	100	15·4	100	15·8	103	15·8	103
1931 ...	2E	1,291	1,038	*Nil*	...	10·6	67	15·8	100	20·6	100	22·9	111	23·6	115
1932 ...	1E	1,934	1,627	12·6	56	20·8	92	22·7	100	20·4	100	20·8	102	20·0	98
1933 ...	3E	1,353	1,260	*Nil*	...	11·9	71	16·8	100	16·7	100	17·3	104	18·4	110
1934 ...	1E	1,580	926	9·3	37	22·4	89	25·1	100	22·8	100	21·3	93	20·2	89
1935 ...	2E	1,288	971	*Nil*	...	17·5	70	25·0	100	33·4	100	33·6	101	33·8	101
1936 ...	3E	1,081	878	*Nil*	...	19·8	82	24·0	100	20·6	100	21·7	105	21·8	106
1937 ...	1E	1,350	992	Destroyed by hail.											
1938 ...	4H	1,276	751	7·8	30	21·3	83	25·6	100	20·7	100	22·5	109	23·3	113
1939 ...	2E	2,130	1,481	1·3	9	10·6	75	14·2	100	24·4	100	25·9	106	26·0	107
1940 ...	3E	905	730	3·8	15	20·8	84	24·9	100	19·9	100	19·4	97	20·0	101
1941 ...	1E	1,532	1,077	12·2	47	24·4	94	25·9	100	17·9	100	18·8	105	19·2	107
1942 ...	4H	1,933	1,233	7·1	31	21·6	93	23·2	100	21·6	100	21·9	101	22·1	102
Average, 13 crops				4·2	20	16·9	82	20·5	100	20·2	100	20·8	103	21·0	104
				s. d.		s. d.		s. d.		s. d.		s. d.		s. d.	
Value of Wheat at 3s. 4d. per bushel ...				14 0		56 4		68 4		67 4		69 4		70 0	
Cost of Superphosphate				...		3 4		6 8		6 8		10 1		13 5	
Net Value of Wheat				14 0		53 0		61 8		60 8		59 3		56 7	

Superphosphate applications prior to commencement of the experiment:—
Paddocks 2E and 3E—None; Paddock 1E—2 crops, total superphosphate 262 lbs. per acre.; Paddock 4 Home—1 crop, total superphosphate 150 lbs. per acre.

TABLE D.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.

Merredin Research Station.—Rate of Superphosphate Experiment—1929-1942.

Year.	Pad-dock.	Rainfall Points.		Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.											
				Low Superphosphate Group.						High Superphosphate Group.					
		Annual.	May-Oct.	No Superphosphate.		75 lbs. per Acre.		150 lbs. per Acre. (Control)		150 lbs. per Acre. (Control)		225 lbs. per Acre.		300 lbs. per Acre.	
				bushels	%	bushels	%	bushels	%	bushels	%	bushels	%	bushels	%
1929 ...	3	1,441	927	20·0	74	25·1	92	27·2	100	25·3	100	25·4	100	25·6	101
1930 ...	8	1,333	823	12·9	46	25·2	90	28·1	100	27·2	100	29·6	109	30·7	113
1931 ...	5	1,225	912	19·5	71	26·9	98	27·4	100	29·1	100	29·3	101	29·4	101
1932 ...	3	1,307	1,113	10·7	42	22·9	90	25·4	100	26·3	100	27·1	103	28·2	107
1933 ...	5	967	784	13·4	62	18·9	87	21·7	100	25·8	100	27·0	105	27·0	105
1934 ...	3	1,348	644	13·2	53	21·9	88	25·0	100	23·4	100	25·0	107	25·3	108
1935 ...	5	1,024	764	6·6	51	11·1	86	12·9	100	12·7	100	13·7	108	13·4	106
1936 ...	3	881	606	3·2	56	5·7	100	5·7	100	5·4	100	5·0	93	4·7	87
1937 ...	8	846	651	8·4	59	14·0	98	14·3	100	16 4	100	15·7	96	15·9	97
1938 ...	3	891	575	7·6	57	12·2	92	13·3	100	12·7	100	13·3	105	13·2	104
1939 ...	8	1,589	1,019	23·9	...	30·2	...	*25·4	...	*23·9	...	*18·9	...	*16·8	...
1940 ...	3	734	502	No crop on account of drought conditions.											
1941 ...	8	1,271	1,020	19·9	59	33·0	98	33·8	100	35·9	100	35·8	100	36·3	104
1942 ...	5	1,461	840	21·6	81	25·6	95	26·7	100	27·5	100	27·8	101	28·5	104
Average, 12 crops				13·1	60	20·2	93	21·8	100	22·3	100	22·9	103	23·2	104
				s. d.		s. d.		s. d.		s. d.		s. d.		s. d.	
Value of Wheat at 3s. 4d. per bushel ...				43 8		67 4		72 8		74 4		76 4		77 4	
Cost of Superphosphate				...		3 4		6 8		6 8		10 1		13 5	
Net Value of Wheat				43 8		64 0		66 0		67 8		66 3		63 11	

* Rank growth with high rates caused lodging and harvester returns incomplete—figures discarded.

Superphosphate applications, 1911-1928 period and known previous applications from available data.—

Paddock 3.—6 crops, 1911-1928 period, total superphosphate approximately 524 lbs.; 2 crops, 1906 and 1908, probably received a total of 150 lbs. of superphosphate per acre.

Paddock 5.—6 crops, 1911-1928 period, total superphosphate approximately 612 lbs.; 1 crop in 1910 received 112 lbs of superphosphate per acre.

Paddock 8.—7 crops, 1911-1928 period, total superphosphate approximately 492 lbs., probably one crop in 1909 received 112 lbs. of superphosphate per acre.

TABLE E.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.

Yilgarn Research Station.—Rate of Superphosphate Experiment—1929-1939.

Year.	Paddock.	Rainfall Points.		Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.											
				Low Superphosphate Group.						High Superphosphate Group.					
		Annual.	May-Oct.	No Superphosphate.		75 lbs. per Acre.		150 lbs. per Acre. (Control)		150 lbs. per Acre. (Control)		225 lbs. per Acre.		300 lbs. per Acre.	
				bushels	%	bushels	%	bushels	%	bushels	%	bushels	%	bushels	%
1929 ...	E	1,071	571	6·5	58	10·4	93	11·2	100	7·4	100	6·0	81	4·8	65
1930 ...	C2	1,189	568	14·1	62	18·0	80	22·6	100	21·2	100	20·7	98	21·8	103
1931 ...	D	1,019	804	10·3	60	15·9	93	17·1	100	17·9	100	19·0	106	18·4	103
1932 ...	E	1,196	940	14·6	74	17·0	87	19·6	100	17·0	100	16·6	98	17·4	102
1933 ...	C2	1,138	859	14·1	61	19·6	85	23·0	100	22·1	100	23·2	105	24·1	109
1934 ...	C1	1,360	633	8·4	42	16·8	84	20·0	100	17·4	100	17·6	101	18·3	105
1935 ...	C2	1,075	806	4·1	29	10·0	71	14·1	100	12·8	100	14·0	109	13·6	106
1936 ...	C1	691	469	1·7	25	5·2	78	6·7	100	5·3	100	5·1	96	4·7	89
1937 ...	C2	996	462	4·7	44	7·9	74	10·7	100	9·9	100	10·8	109	10·5	106
1938 ...	C1	606	368	Not harvested owing to drought.						*2·0	100	*2·8	140	*3·0	150
1939 ...	C2	1,473	854	10·5	62	16·7	99	16·8	100	12·1	100	11·2	92	11·2	92
Average, 10 crops				8·9	55	13·8	85	16·2	100	14·3	100	14·4	101	14·5	101
				s. d.		s. d.		s. d.		s. d.		s. d.		s. d.	
Value of Wheat at 3s. 4d. per bushel ...				29 8		46 0		54 0		47 8		48 0		48 4	
Cost of Superphosphate				...		3 4		6 8		6 8		10 1		13 5	
Net Value of Wheat				29 8		42 8		47 4		41 0		37 11		34 11	

* Excluded from average.

Superphosphate applications prior to commencement of the experiment:—
Paddock C1.—1 crop, about 75 lbs. of superphosphate per acre; Paddock C2.—None; Paddock D—1 crop, 75 lbs. of superphosphate per acre; Paddock E.—None.

TABLE F.—EFFECT OF RATE OF SUPERPHOSPHATE ON THE YIELD OF WHEAT.

Salmon Gums Research Station.—Rate of Superphosphate Experiment—1929-1942.

Year.	Pad-dock.	Rainfall Points.		Yield of Grain in Bushels per Acre and Yield as Per Cent. of Control—150 lbs. per Acre.											
				Low Superphosphate Group.						High Superphosphate Group.					
		Annual.	May-Oct.	No Superphosphate.		75 lbs. per Acre.		150 lbs. per Acre. (Control)		150 lbs. per Acre. (Control)		225 lbs. per Acre.		300 lbs. per Acre.	
				bushels	%	bushels	%	bushels	%	bushels	%	bushels	%	bushels	%
1929 ...	A1	1,173	710	5·0	32	14·4	92	15·6	100	11·3	100	14·1	125	13·2	117
1930 ...	B1	1,623	837	8·2	59	12·7	91	13·9	100	15·6	100	14·8	95	15·2	97
1931 ...	A1	1,669	1,305	8·3	53	15·6	100	15·6	100	17·6	100	17·8	101	18·0	102
1932 ...	B1	1,307	1,005	7·3	30	22·9	95	24·2	100	24·5	100	24·0	98	22·4	91
1933 ...	A1	1,213	676	5·5	31	13·0	72	18·0	100	16·9	100	19·6	116	19·4	115
1934 ...	B1	1,495	682	2·8	22	9·4	75	12·5	100	15·5	100	15·6	101	15·4	99
1935 ...	A1	1,146	628	11·4	75	13·0	85	15·3	100	19·5	100	20·3	104	20·8	107
1936 ...	A3	1,153	719	3·9	44	7·2	82	8·8	100	10·8	100	10·8	100	11·2	104
1937 ...	A1	1,488	695	9·6	62	13·3	86	15·5	100	18·7	100	20·5	110	21·2	113
1938 ...	A3	1,829	1,100	9·5	54	18·4	104	17·7	100	22·7	100	23·6	104	23·2	102
1939 ...	A1	1,900	803	8·6	48	14·7	83	17·8	100	19·0	100	20·3	107	20·8	109
1940 ..	A3	832	522	2·0	62	2·8	88	3·2	100	5·0	100	5·4	108	5·8	116
1941 ...	B1	983	676	5·8	46	11·2	90	12·5	100	13·8	100	13·6	99	14·0	101
1942 ...	A3	2,066	961	8·8	52	14·6	85	17·0	100	15·2	100	15·2	100	16·7	110
Average, 14 crops				6·9	47	13·1	88	14·8	100	16·2	100	16·8	104	17·0	105
				s. d.		s. d.		s. d.		s. d.		s. d.		s. d.	
Value of Wheat at 3s. 4d. per bushel ...				23 0		43 8		49 4		54 0		56 0		56 8	
Cost of Superphosphate				...		3 4		6 8		6 8		10 1		13 5	
Net Value of Wheat				23 0		40 4		42 8		47 4		45 11		43 3	

Superphosphate applications prior to commencement of experiment:—
Paddocks A1 and B1.—90 lbs. per acre; Paddock A3.—290 lbs. per acre.

G.—CONCLUSIONS.

Consideration of the results of all experiments with superphosphate on the research stations, coupled with observations on the growth of bulk crops and trials on a number of private farms leads to the following conclusions:—

1. The most profitable rates of application for the production of wheat for grain in Western Australia—
   - (a) For medium and heavy soils: about 1 cwt. of superphosphate per acre.
   - (b) For light soils and sandplain country: about 130 lbs. of superphosphate per acre.
   - (c) Where land has been well farmed and fertilised for many years these rates could be considerably reduced.

2. The application of superphosphate at seeding is desirable to promote early growth and earlier maturity of the wheat.

3. The residues of former dressings of superphosphate remain in the soil indefinitely and are of great value to succeeding crops.

4. On old, well farmed and previously well fertilised land in the wheatbelt, crop failure due to reduced applications of phosphate need not be feared. Although some reduction in the yield of wheat may result from the application of only 40 lbs. of 18 per cent. superphosphate per acre, it is considered that instances of seriously reduced yields or failure will be due to factors other than the dressing of superphosphate used.

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The Pig Industry.

CARCASS QUALITY.

M. CULLITY, Superintendent of Dairying.

For several years the production of pig meat throughout the Commonwealth has been increasing, and the prices offered by the British Government in its contracts with the Australian Government have been largely responsible for maintaining a tendency to expansion of the industry.

The exports of pig meats from Australia were as follows:—

Year—	tons.
1938-39	13,000
1939-40	24,000
1940-41	33,000

A corresponding increase in production has taken place in Western Australia, where an export trade has been developed:—

EXPORTS OF PIG MEAT—WESTERN AUSTRALIA.

Year—	lbs.
1935-36	1,550,285
1936-37	1,308,864
1937-38	853,701
1938-39	1,277,865
1939-40	5,600,655
1940-41	13,261,795
1941-42	10,450,555

However, since the outbreak of war, on a number of occasions it was found necessary to vary requirements for export—sometimes at short notice. This led to considerable dissatisfaction and in Western Australia at least, early in 1941 to a pronounced decline in pig numbers.

The loss of manpower in rural areas throughout Australia later became more serious, and production tended to decline still further on that account. At the same time due to the increased population, composed of evacuees from Malaya and the Indies and of Allied troops, the demand for pig meat became greater than ever previously. It became obvious that adequate extension of production could not be achieved unless the farmer was guaranteed a satisfactory price for a sufficient period.

It is expected that the Commonwealth Government will shortly announce the details of a plan whereby farmers will be given such a guarantee.

In an endeavour to allow the farmer to gain an idea of requirements, State production targets have been set so that the individual States have some knowledge of the extent to which production may be increased with safety.

For Western Australia, this target has been fixed at 10,000 tons, which is slightly higher than the State has ever produced in any one year. Farmers who are in the position to expand their operations are expected to help as far as they are able in meeting the requirements. The expected pig plan will probably include a schedule of prices allowing greater returns for the best quality animals, so that emphasis will be placed on the need for producing carcasses which will meet the requirements of the market, both at home and on export. If the future of the industry is bound up with the export market the production of high quality carcasses becomes still more important as competition will be met from countries where much attention has been given to the improvement of carcase quality. In Western Australia, therefore, the activities of the pig raisers should be directed towards the production of that type of pig which will not only be most profitable, but will also satisfy immediate market requirements and help to establish a reputation for the local pig.

The farmer can do this by using carefully selected breeding animals and by feeding his trade pigs to allow correct development. A real test of a pig can only be made when it is on the hooks in the treatment works, when its make-up of fat and lean meat can be determined. However, in the live pig some characteristics which indicate a greater probability of suitability or of unsuitability are readily discerned.

In an endeavour to demonstrate to pig farmers the type which should be aimed at, the Western Australian Branch of the Australian Stud Pig Breeders' Association some years ago had prepared to their order a chrome-nickel model of an ideal bacon pig (see figure 1) which has been exhibited at agricultural shows and farmers' lectures. In this model the Stud Pig Breeders' Association has expressed the belief of its members that no matter what breed a farmer may elect to use, the importance of producing pigs which will satisfy the commercial bacon requirements should be fully realised.

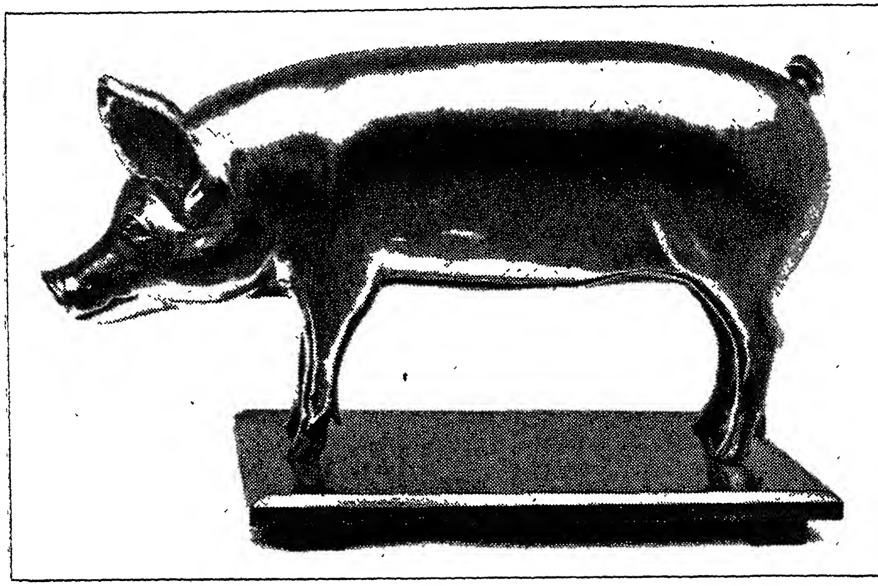

Fig. 1
Model of standard type of bacon pig prepared by the Western Australian Pig Breeders' Association as a guide to breeders and farmers in the selection of breeding stock for bacon production

As mentioned earlier, the real test of a pig is when it is on the hooks, when the characteristics of its carcass can be determined, in order to see to what extent it meets commercial requirements. A carcass which will prove suitable for the trade and obtain top prices is one which has maximum meat development and which has an even but not heavy layer of fat. It will be light in those cuts which are low priced (e.g., the shoulders), and well developed in those parts which demand high prices (e.g., the hams).

This type of carcass can only be produced if the breeding animals can transmit the characteristic of lengthy middles to their progeny: the lengthy middle portion allows the development of carcasses which will not be unduly fat while they supply a large amount of lean meat.

A pig which is long for its weight will usually prove to be less fat than one which is short at the same weight. The more lengthy pig, in addition, will give a greater proportion of back cuts than belly cuts, the latter being cheaper than the former.

The back of the pig should be slightly arched from head to tail. The shoulders must not be heavy, or coarse, but light, smooth, and tapering slightly or rounded, rather than broad and flat; they are a relatively low priced part and when they form a smaller proportion of the whole carcass, it is considered desirable.

The pig which is likely to yield an unsuitable carcass is one which is short and which, therefore, at bacon weights is deep and wide. On slaughter such a pig will show a very thick layer of fat on the outside of the muscular parts. The fore-quarter will probably be heavy and the whole carcass one from which it is impossible to get cuts which will satisfy the buyers in the retail shops.

The pig which at time of slaughter is lengthy, not excessively deep, and has a clear cut underline will usually meet these requirements.

The difference between suitable and unsuitable sides is illustrated in Fig. 2 with two sides of equal weight.

Fig. 2.

Short undesirable side with too thick a layer of fat along the back compared to a lengthy side. Both sides are the same weight. Ministry of Agriculture Report on Empire Pork and Bacon Trades, 1928.)

Between the vertical processes of the backbone and the ribs runs a muscle lengthwise along the back of the pigs; this forms the eye of the meat in the cut through the loin and in the bacon rasher. To provide a seating for this muscle and to allow adequate room for its development, the ribs must be well sprung and not slope rapidly downwards from the backbone. They, however, should not be too rounded, but in the finished pig there should appear to be a distinct break from back to side. The backfat should be even without any pronounced thickening over the shoulder and should measure not more than 1½ inches.

A thick streak (over 1½ inches) with plenty of lean meat is desirable. Thick bellies are frequently produced by over-fattening. These are deficient in meat and

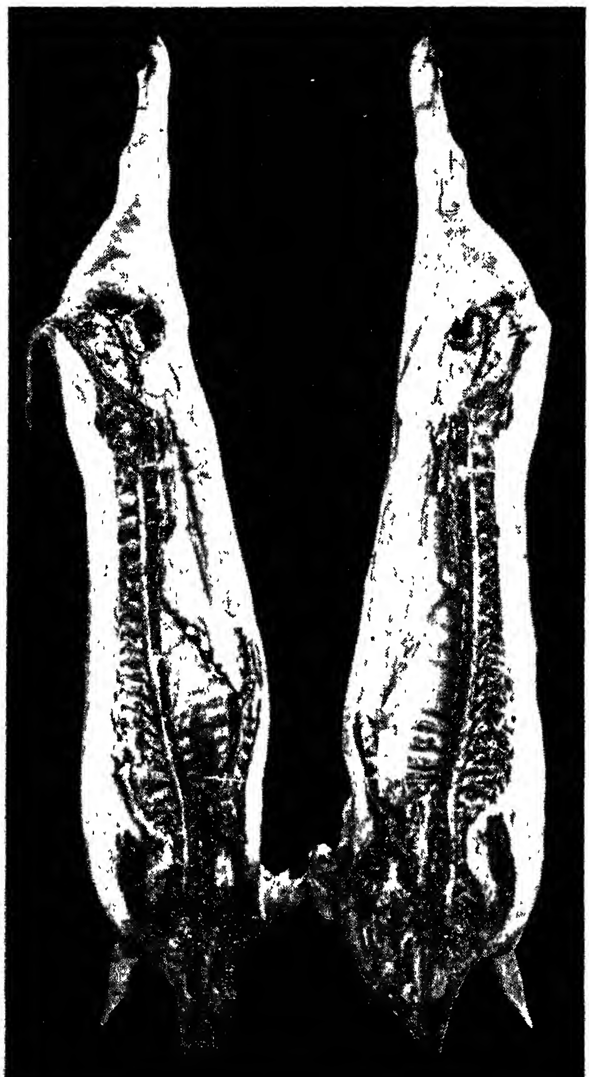

Fig. 3.
A heavyweight overfat carcase.

do not fill the requirement of a thick streak which is thick because of the muscle development rather than fattening.

The combination of a thick meaty streak with a well developed "eye" muscle and thin backfat gives the sort of pig meat demanded by the public.

The hams should be well filled out with lean meat extending down to the hocks. The space between the legs when U rather than V shaped suggests better development.

The *fat in the carcass* should be firm—a soft oily fat is objectionable from the point of view of the purchaser. The firmness is influenced more by feed than by breed, and by the rapidity of growth, a fast growing pig will usually show firmer fat than a slow growing one. This fact again is probably most frequently due to the differences in the amount and kind of feed which influence the rate of growth.

The character of a carcass, however, is not regulated solely by the breed and type of the parents. Feeding affects the size, muscle or lean meat development and the amount of fat and accordingly it is possible to feed pigs of similar inherited type so that they will appear quite dissimilar at equal bacon weights. The influence of feeding on experimental pigs at the Muresk Agricultural College is shown elsewhere in this Journal.

A study of the plates, particularly 7 and 8, will show difference in growth between pigs of same litters receiving different mixtures, while the sides and loins of the pigs representing groups 1 and 2 show pronounced differences in the development of the lean meat and accumulations of fat.

The classic experiments of McMeekan and Hammond have shown that the proportions of fat and lean meat in the carcass of the pig can be varied very considerably by adjusting the quantity and composition of rations.

The importance of providing the young and growing pig with a full properly balanced ration in order to allow full development of the skeleton and of the muscular system was demonstrated. The fact that the bone and muscle development takes place most rapidly in the early months when sufficient feed is provided and that fat deposition becomes rapid only after bone and muscle growth has slowed down, proves the most useful guide to farmers in growing pigs of the right type. Full feeding in the early stages with some restriction in the quantity fed when the pig is four to five months of age, is the method which will prove satisfactory. The free unrestricted form of feeding leads to the production of a pig which reaches bacon weight before it has finished making full skeletal growth and is accordingly shorter and fatter than desirable.

Feeding a restricted quantity in the early months and then speeding up to "top off" accentuates the condition described above. Bone and muscle growth is restrained and as the pig reaches maturity additional feed is given which results in a short fat pig.

The expected new system of controlling purchase of pig meat will, because of the differences in price to be paid according to the grade of the carcass, tend to encourage farmers to forward the type of pig which will be classified as top quality. To do this proper selection of breeding stock is the first step, as while pigs of good inherent type may be spoilt by improper feeding, pigs of poor inherent type cannot be built into good pigs by feeding.

Having good stock to begin with, feeding a properly balanced ration, so as to encourage bone and muscle development will provide marketable pigs of top quality.

It is not sufficient for the farmer to produce pigs which will meet the requirements as described, but in addition care is needed to ensure that the animals will reach the bacon factory in an unblemished condition.

A visitor to any treatment works will be impressed by the damage to carcasses which occurs through rough handling. The use of dogs, kicking, prodding with sticks or other similar methods of moving pigs, results in bruises which mar the carcass. The bruised flesh is useless and has to be removed. (See plate 4.)

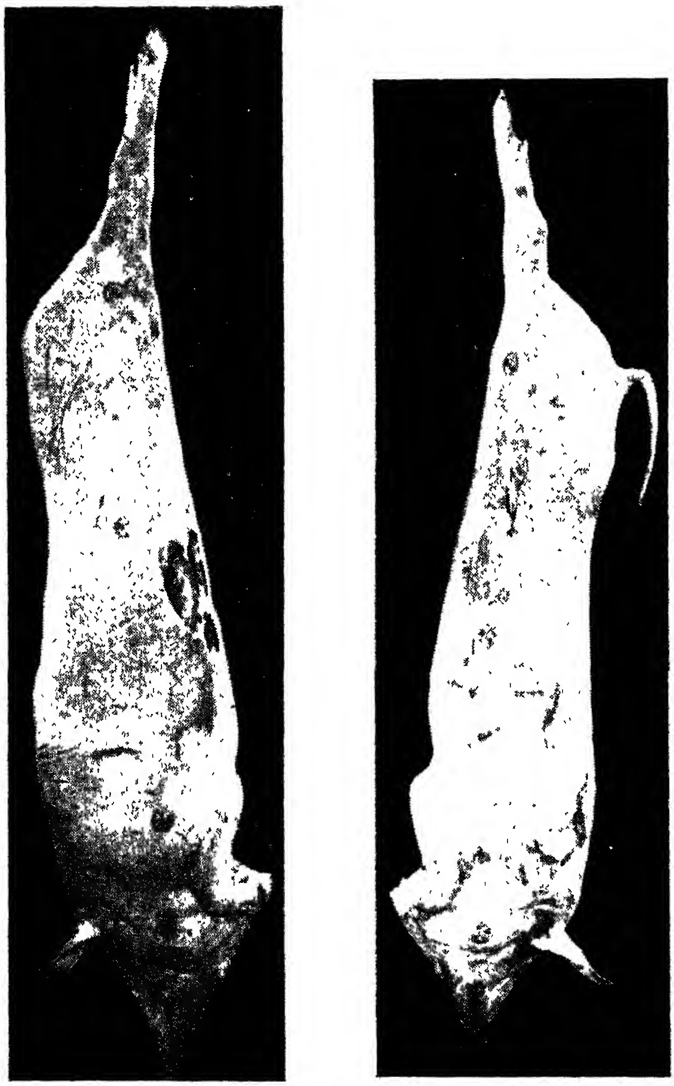

Fig 4.
Carcases blemished with bruises and with scoring of the skin.

Many blemishes which are only skin deep, but nevertheless spoil the "finish" are caused in a similar war, as well as by the use of barb wire fences, badly constructed pens and loading appliances. Fighting among the pigs also causes marks which persist after slaughter.

The Cabbage Butterfly.

(*Pieris rapae* L.)

A RECENTLY INTRODUCED PEST.

C. F. H. JENKINS, M.A., Government Entomologist.

The Cabbage Butterfly is a well known pest of cabbages and cauliflowers in many parts of the world. Its native home is Europe but in 1858 it was accidentally introduced into North America, and since then it has spread to many countries, including Hawaii, New Zealand, and Australia. The first record for Australia came from Melbourne in 1939, and since then its spread has been rapid, for by the end of 1940 it had reached Tasmania, New South Wales, and South Australia.

In an effort to prevent the pest reaching this State regulations were early gazetted prohibiting cabbage and other plants likely to harbour the insect being sent to Western Australia from affected areas. Unfortunately these measures proved of but little avail, as early in January, 1943, the first Cabbage Butterfly was caught at Bassendean in a backyard vegetable garden.

Investigation further afield soon showed that the pest had reached other suburban districts, including Midland Junction and Cannington, as well as the Hills localities of Parkerville and Mundaring.

How the pest reached Western Australia it is difficult to say but there seems little doubt that despite quarantine regulations infested vegetable material has entered the State.

An example such as this shows how easily new pests may be introduced into a country and how important it is for all individuals to co-operate in helping to make quarantine measures as effective as possible.

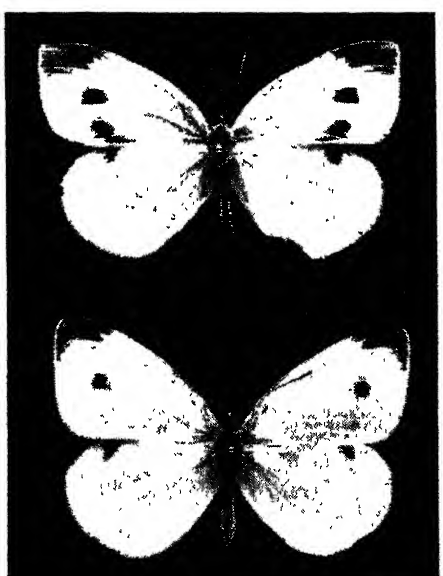

Fig. 1.
Cabbage Butterfly. (Upper) female; (lower) male.

The Cabbage Butterfly must not be confused with the Cabbage Moth. The latter is a tiny greyish insect, the small green caterpillars of which are well known to all cabbage and cauliflower growers. The Cabbage Butterfly, on the other hand, is a large conspicuous butterfly which has only just established itself in Western Australia.

Butterfly.

The butterfly is white marked with black or very dark brown near the tips of the forewings, and has a wing spread of about two inches. There is some variation in size and the males are usually a little smaller than the females. In addition, the female has two black spots on each forewing, whereas the male has only one spot. The hind wings in both sexes have a single black spot near the front margin and are pale yellow on the underside.

This insect should not easily be confused with any native butterflies in this State, for the only common white butterfly in the South-West is rather larger in size, has more black markings, and shows some conspicuous red spots when the wings are held erect over the back.

Egg.

The pale yellow eggs of the cabbage butterfly are bullet shaped and just visible to the naked eye. Under a lens it will be noticed that they are ribbed and sculptured in a characteristic manner.

Caterpillars.

The caterpillars are velvety green in colour with a faint yellowish line running down the centre of the back. They measure about $1\frac{1}{4}$ inches in length when full grown.

Chrysalis.

The chrysalids or pupae measure about one inch in length and are usually greenish or greenish yellow in colour, but they may vary considerably according to the background.

HABITS AND LIFE HISTORY.

Accurate details concerning the life history under local conditions are of course not yet available, but experience in other States may be taken as a satisfactory guide.

The butterflies may be expected to appear early in the spring, when they will fly over vegetable gardens looking for suitable food plants. A single female may lay up to 400 eggs which are deposited singly on the leaves, usually on the under surface near the edge.

The egg stage lasts about a week, the time varying according to weather conditions. The caterpillar stage may last about two to three weeks and the chrysalis or pupal stage about a week or ten days, so that from the laying of the egg to the appearance of the butterfly may occupy a month to six weeks. Breeding will continue during favourable weather conditions, and so several generations can occur annually.

When fully fed the caterpillars may pupate on the food plant or wander away to a neighbouring fence or tree. Here they will secure themselves to a suitable support by a silken loop and undergo the change into the winged adult.

Fig. 2.
A. Caterpillar and B. pupa or chrysalis of Cabbage Butterfly on leaf.

When very small it may be difficult to distinguish the green caterpillars of the Cabbage Butterfly from the Cabbage Moth, but the moth caterpillar, when touched or disturbed usually wriggles and squirms very actively, often dropping and suspending itself from a leaf by a silken thread, whereas the butterfly caterpillar is usually rather sluggish.

Host Plants.

The caterpillar has been recorded as feeding upon lettuces and all cruciferous plants such as cabbages, cauliflowers, turnips, kale, radish, stocks, etc., but cabbages and cauliflowers are the favourite food plants.

Economic Importance and Type of Injury.

The Cabbage Butterfly is a very serious pest in European countries; whether it will prove to be equally serious in this State it is yet too early to say. There is no doubt, however, that if neglected it will cause serious damage to various vegetable crops.

Fig 3.
Cabbage injured by caterpillars of the Cabbage Butterfly
Note caterpillar feeding on heart

The injury caused is very similar to that done by the Cabbage Moth caterpillar, excepting that as the butterfly caterpillar is much larger than that of the moth the injury it causes is more gross. The leaves of food plants may very soon be holed and even skeletonised if control measures are not adopted.

CONTROL.

Fortunately the routine control measures adopted by most growers against the Cabbage Moth should be effective against the Cabbage Butterfly. It should be realised, however, that where this new pest is established the need for exercising these control measures will be even more drastic.

A careful watch should be kept for the first signs of Cabbage Butterfly injury, so that action can be taken early. Young plants can be sprayed or dusted with arsenicals without danger, but the use of arsenate of lead should be discontinued at least six weeks before the plants are ready to cut. If thorough treatments are given at the early stages it is often possible to so reduce the pest that mature vegetables can be easily protected by other measures.

Arsenical Dusts and Sprays.

A dust consisting of equal parts of arsenate of lead and slaked lime, kaolin, or some other inert carrier will give the best control. The mixture may be applied

either with a dust gun or shaken on through the meshes of a bag or some other suitable fabric.

When arsenate of lead sprays are used the mixture should be applied at the rate of ½ ounce of powdered arsenate of lead, or 1 oz. of paste to one gallon of water. The mixture must be kept thoroughly agitated while in use, as the arsenate of lead is not soluble and will gradually settle to the bottom. The addition to every gallon of about 1 oz. of flour mixed to a paste (or a proprietary spreader) will help the spray to adhere to the foliage.

Treatments should be repeated about every ten days or a fortnight according to the severity of the infestation. But it cannot be too strongly emphasised that one treatment given to check an incipient outbreak is worth half a dozen given after the pest has gained a firm hold.

Non-Poisonous and Nicotine Dusts and Sprays.

If it is found necessary to treat hearting cabbages or cauliflowers, a non-poisonous dust such as derris 1 part and kaolin 8 parts, can be used. The mixing of derris with slaked lime is not recommended. Various proprietary lines containing derris are available. Derris is somewhat slower in its action than arsenate of lead, but has been definitely proved effective against the cabbage butterfly caterpillar.

Dual-purpose Dusts.

Nicotine dusts or sprays will also be found effective and may be prepared as follows:—

(i) Nicotine sulphate or Black Leaf 40, 1½ teaspoonfuls; soap, 1 oz.; water, 1 gallon.

(ii) Nicotine sulphate or Black Leaf 40, 1 part; slaked lime, 16 parts.

Where aphis as well as caterpillars have to be dealt with the following mixtures make useful dual purpose dusts:

1. Arsenate of lead, 8 parts; slaked lime, 8 parts; nicotine sulphate, 1 part.

If nicotine sulphate is not available the following is suggested:

2. Arsenate of lead, 3 parts; slaked lime, 1 part; tobacco dust, 2 parts.

Other useful dusts are:

3. Derris, 2 parts; kaolin or talc, 14 parts; nicotine sulphate, 1 part.
4. Derris, 1 part; slaked lime 1½ parts; sulphur, 1½ parts; tobacco dust, 1½ parts.

Where only small quantities of dust have to be mixed, this can usually be done in a tin. The nicotine sulphate should be sprinkled over the dust and if possible a close-fitting lid should be placed on the tin while it is thoroughly shaken up after the initial stirring. One or two small stones in the tin will assist the mixing.

Where large quantities of material are required a barrel on a stand and axle and revolved like a churn is advisable. Again the addition of a few stones will help the mixing.

Cultural Control.

All old infested plants should be destroyed and as far as possible seedlings should not be planted close to areas previously laid down to closely related crops.

When cutting cabbages, etc., the whole plant should be pulled up so that the butt is not left to act as a harbour for pests.

The destruction of weeds of all kinds should be carried out as a routine practice, no matter what pest it is desired to control.

Biological Control.

Very favourable results are being obtained in New Zealand from the use of a wasp parasite (*Pterolamus puparum*) introduced from Europe. The wasp attacks the pupa of the host and prevents the development of the adult butterfly.

IMPORTANT!

As the Cabbage Butterfly apparently has a limited distribution up to the present time, growers are asked to keep a constant watch for the pest and to report outbreaks immediately to the Department of Agriculture.

Copper Deficiency in Sheep.

H. W. BENNETTS, D.V.Sc.

It is now known that large and widely separated areas of this State, particularly in the south, are deficient in copper. The degree to which various types of country are affected varies considerably; in the more deficient areas stock constantly show some signs, whereas in less affected areas evidences of deficiency may be apparent in certain seasons only. Seasonal conditions, in fact, exert a marked influence throughout; in general, stock are most markedly affected during the winter months and in good years when there is a flush of feed.

Sheep appear to be particularly susceptible to the deficiency and the state of the flock, especially the wool quality, is a good index of the general copper status of the areas on which the sheep are depastured.

SIGNS OF COPPER DEFICIENCY.

In adult sheep these are three:—"Stringy wool," anaemia and excessive scouring.

"Stringy wool" occurs even when pastures are deficient to such a mild degree that all other signs are indefinite or absent. In fact the absence of this wool defect in a clip, predominantly of the merino type, can be taken as reliable evidence that stock are receiving adequate copper from the pastures, provided, of course, that copper is not being supplied through bluestone worm drenches, etc.

The characteristics of "stringy wool," sometimes referred to also as "slippery" or "straight steely" wool, are loss of crimp and straight, glassy or silky appearance; the fleece lacks "bulkiness." The defect is much more noticeable in merino than British breed types.

The anaemia and excessive scouring, associated with a fairly severe degree of copper deficiency, occur particularly in the breeding ewes and are noted, generally, only during the winter months. Obviously both anaemia and scouring may

be due to many causes other than copper deficiency and in the absence of the characteristic sign, "stringy wool," they cannot be taken as an indication of deficiency.

In *lambs* the characteristic sign is ataxia, popularly and quite wrongly known as "rickets." This disease, definitely due to copper deficiency, affects lambs from birth to when about four months old; very rarely older animals are affected. Typically there is some check in growth followed by a loss of control of the hind legs which at first is noted during driving, when movement becomes progressively more difficult. Finally the hind quarters sway ("sway back") and the affected lamb falls over and is only able to proceed again after resting. The condition gets progressively worse until in the course of days or weeks the lamb can travel only short distances or not at all.

The characteristic inco-ordinated gait (ataxia) results from degeneration of the nervous system and should not be confused with the stiffness and lameness seen in arthritis, an infectious disease.

More rarely copper deficient lambs are born dead, or are affected at birth or when a few days old with a rapidly fatal disease in which there are signs of brain involvement. In general the earlier the lamb is affected the more rapid and fatal is the course of the disease. Usually lambs do not show signs until about four to eight weeks old; these may survive for weeks and although the majority die others may grow to maturity. Some abnormality of gait, however, almost always persists.

The numbers of lambs affected and the course taken by the disease is related to the degree of copper deficiency and may vary considerably from year to year, particularly in areas not severely deficient. *It has been shown quite definitely that a degree of deficiency insufficient to cause ataxia may, however, retard the growth and development of lambs to quite a marked extent.*

THE CONTROL OF COPPER DEFICIENCY.

Measures to prevent, or to arrest the effects of copper deficiency in the flock may take the form of:—

1. Direct administration of copper supplement in the form of licks or drenches.
2. Indirect administration by increasing the copper content of pastures to satisfactory levels by topdressing with copper compounds.

The former method of supplementation is very cheap. It is recommended principally where it is uneconomic to topdress any considerable area, e.g., where the country is predominantly of a light type carrying unimproved pasture. Where, however, good quality pasture species are being encouraged (N.B., subterranean clover which has a high copper requirement) or where cereal crops show evidences of copper deficiency, the extra cost of topdressing will be more than compensated for by the resultant improved quality and/or quality of the herbage. All sheep depastured thereon must receive a regular and adequate supply of copper whereas this cannot be guaranteed when copper supplements are fed under practical farming conditions. In this connection it has been shown by experiment that sheep receiving small amounts of copper at frequent intervals do better than those taking it irregularly, even in large doses. The choice of methods, however, will depend largely on economic and practical considerations.

It should be noted that copper is a poison and that excessive supplementation may result in a disease, characterised by redwater and jaundice, and which is fre-

quently fatal. It is very unlikely that topdressing could raise the copper content of herbage to dangerous levels, but the *uncontrolled* use of salt-copper licks, particularly on copper-dressed country, should not be permitted.

Licks.

A bluestone-salt lick is recommended. The strength used depends on the amount of lick consumed by the sheep.

In general the following has been found satisfactory:—Bluestone ¼lb.; salt 100 lbs.

Consumption of this lick at the rate of about 2 oz. per sheep per week will give an adequate copper supplement. More than double this amount can be taken with complete safety. If after a few weeks, the intake is considerably in excess of or is below the amount recommended, the strength of the lick should be adjusted proportionally.

To mix the lick, dissolve the required amount of bluestone in a small quantity of water in a non-metal container. Sprinkle solution over the salt and then mix in until colour is uniform, indicating that the bluestone is evenly distributed throughout; a spade is useful for mixing.

Lick should be fed throughout the year for the best results, but particularly during the in-lamb period and throughout the winter months. During the wet season the lick must be protected from the weather, otherwise rain will wash out a considerable proportion of the bluestone which is readily dissolved away from the outside of the grains of salt.

The lick is taken well by sheep in the more inland copper deficient areas.

Drenches.

Drenching has only a limited usefulness. Its main value would be for the arresting of ataxia; lambs showing early signs of the disease may be reared satisfactorily if given a bluestone drench daily or at least three times a week. For this purpose first make a *strong* solution by dissolving 1 oz. bluestone in 2½ pints water. To make a *dilute* solution for drenching, take one fluid ounce (two tablespoonsful) of the strong solution and add water to make up to one pint. Give one fluid ounce of the *dilute* solution daily or two fluid ounces three times a week. Do not use metal containers for making up or storing solutions.

In cases where for some reason*, it is impracticable to supplement the diet of the in-lamb ewe in either of the other two ways drenching may enable it to build up adequate reserves of copper to prevent the occurrence of ataxia in the lamb born subsequently. For this purpose the full "worm" dose of bluestone may be administered at monthly or more frequent intervals. This procedure naturally, is less satisfactory than the recommended methods.

Topdressing with Copper.

The copper content of mixed pastures, in deficient areas, can be raised to normal values following topdressing with copper compounds mixed with superphosphate.† Sheep grazed on such pastures receive adequate copper and in general

* Licks do not appear to be taken readily on "coasty" country, particularly where large unsubdivided areas are grazed. Under these conditions drenching with copper (and cobalt) supplements has given satisfactory results. Bennetts, H. W., Journal Department of Agriculture, W.A., 17 : 41, 1942.

† Cereals which are poor collectors of copper differ in this respect However, herbage growing with the cereal. and subsequently, will have an increased copper content and thus supplement the intake of sheep grazing the cropped areas.

do very well. This is the ideal method of supplementation provided it is economically justifiable, i.e., if increased pasture and cereal yields warrant the extra expenditure.

For topdressing either bluestone or oxidised copper ore mixed with superphosphate, is recommended. The initial dressing should be equivalent to 5-10 lbs. bluestone to the acre. This is very probably effective for more than one season, but until further information is available it is recommended that light dressings equivalent to 2 lbs. bluestone per acre be applied each subsequent season.

THE DISTRIBUTION OF COPPER DEFICIENCY.

We have ample evidence that "stringy" wool, and to a less extent ataxia, will occur in any of the areas known to be copper deficient, and in fact the occurrence of "stringy" wool has been used to indicate areas which are incipiently deficient.

In a number of districts, where copper deficiency diseases of animals were first recognised and studied in 1936, large tracts of land are deficient so that stock depastured almost anywhere throughout showed definite evidences of deficiency.

In other parts of the State, however, notably in the wheat belt, only certain types of land are deficient so that individual properties may be made up of a variable proportion of deficient and healthy country. Whether stock show signs of deficiency would depend primarily upon the class of country to which they have had most access during that particular year.

It should be noted that experience in the affected areas clearly shows that the evidences of copper deficiency become progressively more manifest with time and with the increased rate of stocking which follows clearing of the country, the elimination of natural scrub, and the development of improved pastures. In effect country which in its unimproved state carried stock satisfactorily may, following development, no longer do so.

Copper deficiency has been shown to be widespread through the following areas:—

(a) Gingin and Dandarragan.

(b) The South-West—the jarrah, redgum country around Mt. Barker and in the Busselton, Margaret River and Northcliffe districts is to a very great extent severely deficient.

(c) "Coasty" country. The wind-blown sand dune type appears to be quite generally deficient in copper, evidence being available from as far north as Broome to Hopetoun on the south coast. (Generally there is a complicating deficiency of cobalt also which gives rise to the wasting characteristic of "coast disease"). Semi-coastal country further inland is frequently copper deficient also (e.g., around Albany).

Areas in which copper deficiency is irregularly distributed instead of generally.

These have not been studied so completely yet, but it is clearly evident that such areas are widespread throughout the State. In this connection "stringy wool" has been recorded as far inland as Kukerin and Kondinin in the south and Dalwallinu and Mukinbudin in the north.

(a) in the South-West. Forest country, other than areas mentioned above, e.g., Denmark, Manjimup, Pemberton.

(b) Great Southern and Wheat Belt areas. "Stringy wool" has been reported from a large number of widely distributed properties on some of which ataxia occasionally occurs also, e.g., at Kwolyin, Corrigin, Bulyee and Tambellup.

In some localities only occasional properties are affected, in others as in the vicinity of Corrigin rather large areas are affected.

Investigations have indicated that the types of country likely to be affected are light sandy (or sandy, gravelly) soils carrying predominantly white gum, tamma, wodgil, or white gum, associated with stunted jam and casuarina, although these vegetation associations do not necessarily indicate copper deficiency. It appears quite evident, however, that heavier forest country carrying salmon gum or york gum is quite healthy and where sheep have adequate access to this, as well as to the lighter types, they are able to obtain sufficient supplies of copper for all bodily needs.

SUMMARY.

1. The characteristic signs of copper deficiency in sheep are "stringy wool" and ataxia; the former may indicate only a mild degree, the latter is evidence of a more severe degree of deficiency.

Other signs are anaemia and excessive scouring of sheep and slow growth of lambs.

2. These can all be prevented by the use of copper supplements which may be given as a lick (a drench) or by topdressing with copper compounds mixed with superphosphate.

3. Copper deficient areas are widespread throughout the State. Some of these areas are markedly and rather generally affected so that stock show evidences of deficiency on most properties. In other parts of the State (N.B., the Wheat Belt) only certain types of country appear to be deficient and both deficient and healthy country may occur on individual properties within these areas. The presence or absence of signs of copper deficiency in sheep carried depends primarily upon what types are grazed.

"Stringy" wool from Mount Barker.
[Photo. Govt. Print.]

Healthy Merino Wool.
[Photo Govt. Print.]

Wilt Diseases of Tomatoes.

W. P. Cass Smith, Plant Pathologist.

The term "tomato wilt" is very confusing to tomato growers in general, and to inexperienced home gardeners in particular, for they naturally assume that it refers to a single disease. Letters are frequently received from worried growers telling of the losses caused by "tomato wilt" and asking for the best methods of treatment. However, unless diseased specimens are also forwarded or the symptoms carefully described, it is impossible to advise them definitely, for in Western Australia symptoms of this general type may be produced by three entirely different diseases, each of which requires different treatment. Two of these, namely, Fusarium and Bacterial wilt of tomatoes, are caused respectively by fungal and bacterial parasites, while the third, known as spotted or bronzy wilt, is caused by a virus.

Fusarium and Bacterial wilt may both be transmitted with the seed or contaminated soil, whereas spotted or bronzy wilt is not disseminated by either of these means.

SPOTTED WILT OF TOMATOES.

Spotted wilt was first recorded in this State in 1923 in the metropolitan area. Since then it has spread to many other parts, including the main tomato growing areas. In commercial crops losses vary considerably from year to year, but on the average it is easily the most serious disease of tomatoes, annually affecting thousands of plants.

In the metropolitan area it is always a serious menace, so much so, that the successful cultivation of tomatoes in home gardens is now most precarious.

Symptoms.

The disease may attack plants at any stage of growth, and one of its most striking features is the suddenness with which it develops. Tomatoes which appear vigorous and healthy one day may on the next show a wilting of the topmost leaves which tend to curl downwards and inwards. Shining bronze or copper-coloured spots also appear on the youngest foliage (Plate 1) and within a few days the spotted leaves shrivel and die. Occasionally tomato plants are killed outright by the disease but this occurs most frequently when young seedlings become infected. Usually the plant is not killed but growth is arrested and the dwarfed plants may struggle along unthriftily for months.

The fruit of affected plants may ripen normally, especially when it is well developed prior to infection; on the other hand, it often shows yellowish markings which range from an irregular mottle to very distinct concentric circles, and such fruit is watery and of poor quality (Plate 2). Spotted wilt is caused by an infective principle or virus which is transmitted from diseased to healthy plants by two species of thrips—the onion thrips and the black carnation thrips. If these insects while still in the larval stage suck the sap of a plant affected with spotted wilt, they become infected with the virus and to the end of their lives they are capable of transmitting it to healthy tomatoes or other susceptible host plants. After infection the virus multiplies rapidly in the living cells of the host, but only after several days have elapsed, during which the virus spreads throughout the plant, do symptoms of the disease appear. It will be apparent therefore, that spotted wilt cannot be checked by cutting off affected young tomato foliage, or, that plants showing definite symptoms are the only ones infected with the virus.

Plate 1.
Tomato leaf showing symptoms of the spotted or bronzy wilt virus. The disease first becomes evident on the upper surfaces of the youngest foliage where shining bronze or copper coloured spots appear. The spots may be so numerous that a characteristic sheen is imparted to affected leaflets.

"Wilt-Resistant" Varieties.

From time to time varieties are offered for sale, with the claim that they are "wilt-proof" or "wilt-resistant" and in order to avoid a repetition of past troubles, growers are sometimes persuaded to purchase seed or seedlings. Many of these growers have since bitterly complained that these claims were quite unjustified, for the varieties proved to be susceptible to spotted wilt. It cannot be too strongly emphasised that resistant varieties are only available in the case of Fusarium wilt, and none of the commercial varieties grown in this State have shown resistance to spotted wilt. Growers who purchase seed or seedlings of these so-called "wilt-resistant" varieties should insist that the specific disease for which resistance is claimed is also named.

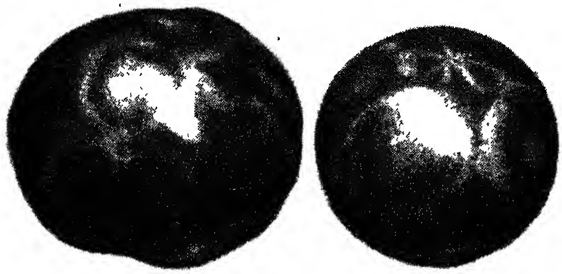

Plate 2.
Yellowish concentric markings on ripe tomatoes affected with spotted wilt.

Host Range.

The control of tomato spotted wilt is complicated by the fact that many flower garden plants and common weeds are also affected by the disease. By harbouring infected thrips these plants perpetuate spotted wilt and increase the sources from which infection may spread to tomatoes.

According to Smith (1937*), the disease has been recorded on more than 100 species of plants belonging to 19 different families, and this number is continually being added to. Susceptible plants listed by Smith include:—

Ornamentals.—Petunia, delphinium, iceland-poppy, begonia, lupin, aster, nasturtium, dahlia, zinnia, chrysanthemum, anemone, ranunculus, salpiglossis.

Common Weeds.—Plantain, black nightshade, dock, sorrel, milk thistle, arum-lily.

Naturally occurring symptoms of spotted wilt have been observed locally on most of the abovementioned plants and in addition the common capeweed is suspected of being an important weed host.

The symptoms shown by these alternate host plants may vary widely from those developing on the tomato, and in consequence the disease is seldom recognised as spotted wilt by the grower, although he is often well aware that the plants are unhealthy (Plates 3 and 4). Common symptoms, often indicative of spotted wilt, include distortion, spotting or partial killing of leaves and floral parts, together with a general stunting of growth.

Control Considerations.

From what has been said it will be appreciated that the complete control of spotted wilt of tomatoes depends on the elimination of insect carriers combined with the eradication of diseased plants. In practice this has proved to be an impossible task for, except in glass-houses, the common contact insecticides have only partially controlled the thrip carriers, while the varied symptoms shown by a vast and seemingly never-ending number of widespread host plants preclude the possibility of destroying all diseased plants. In home gardens, in the metropolitan area or large towns, losses from spotted wilt are relatively much greater than in commercial plantings, because the growing of tomatoes in close proximity to susceptible ornamentals cannot be avoided.

*Kenneth M. Smith. Text book of Plant Virus Diseases, 1937.

Plate 3.

Dahlia leaf showing spider web-like, concentric markings of spotted wilt. Dahlias are very commonly affected with the disease, and are an important host, for through the medium of infected tubers the disease is perpetuated year after year, and transported to new areas.

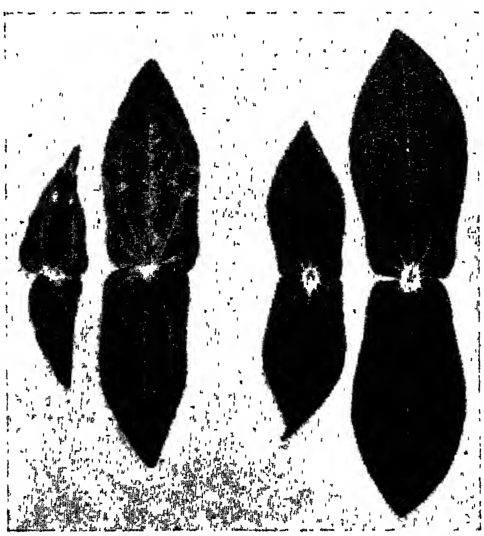

Plate 4.

On left, two zinnia leaves showing symptoms of spotted wilt, produced by mechanical inoculation. On right healthy (control) leaves.

[After Bald & Samuel. C.S.I.R., Bull. 54.]

Under commercial conditions this difficulty seldom arises, and by paying particular attention to "sanitation practices" the spread of the disease can be limited in most years.

In commercial plantings the protection of young plants in seed-beds is of the utmost importance, for rapid transmission of the disease may occur at this stage unless adequate precautions are taken. This was well illustrated in the Geraldton area last year, when a grower with insufficient seedlings of his own

raising, obtained surplus plants of the same variety from a neighbour. Shortly after planting out, a high proportion of the introduced seedlings developed spotted wilt, whereas the grower's own plants were quite healthy.

Outbreaks of spotted wilt have a'so been noticed following the use of sewage sludge. This manure often contains innumerable tomato seeds, and unless the seedlings are eradicated at an early stage they harbour infected thrips and serve to "breed up" the disease.

Recently it has been announced both from South Africa and New South Wales that a tartar emetic foliage bait has given promising control of thrips, thereby reducing the incidence of spotted wilt considerably. Unfortunately this material is not available at present, but efforts are being made to import it. The formula recommended is tartar emetic 2 ozs., brown sugar 4 ozs., water 4 gallons. The bait is applied twice a week to the plants in seed-beds, and once or twice a week, later, when planted out; for seed-bed purposes the amount of tartar emetic may be reduced by half in the above formula.

It is possible that the use of this bait will revolutionise methods of spotted wilt control, but until this can be proved under local conditions, strict attention should be paid to the following points which will assist, at least to some extent, in checking the disease:—

Control Measures for Commercial Growers.

1. In country districts where the disease has not yet been noticed, always grow tomatoes and common garden-flowers from seed. Tomato or ornamental seedlings obtained from the metropolitan area or elsewhere where the disease exists may introduce spotted wilt.

2. Locate seed-beds in well cultivated ground well away from headlands or other places harbouring weeds. If both early and main crops are to be grown select well separated sites for each seed-bed.

3. Apply contact insecticides frequently to the young seedlings. Prepared white spraying oil 1-80 plus nicotine sulphate added at the rate of one teaspoonful per gallon of the oil spray is useful for this purpose, and both may be combined with a routine Bordeaux-mixture spray.

4. Carefully inspect the seed-beds at frequent intervals and remove and destroy plants showing symptoms of the disease.

5. Plant out on to land which has been well worked to destroy weeds and endeavour to keep down weed growth during the growing season.

6. After planting out include contact insecticides in sprays, or dusts, applied to control fungal diseases or chewing insects, and remove and destroy diseased plants as soon as noticed.

Control Measures for Home Gardeners.

1. As (1) under measures for commercial growers.

2. If seedlings are purchased, carefully examine and select plants free from suspicious looking symptoms.

3. If growing from seed, sow directly in the positions where the plants will remain. Several seeds slightly separated may be sown in each position; this will provide transplants if germination is faulty and will allow any diseased young plants to be removed and destroyed, without leaving "misses." Ultimately, when the plants are well established, thin out, leaving the most vigorous plant in each case.

4. Observations over a number of years indicate that plantings made from mid-December to mid-January, are usually less affected by spotted wilt than spring plantings.

5. Grow the plants in well-cultivated soil kept free of weeds and as far away as possible from flowers.

6. During growth keep the plants well dusted with a mixture containing 10 parts basic copper carbonate, 40 parts flowers of sulphur, and 50 parts air slaked lime. This will largely control fungal leaf spotting diseases and may give some control of thrips also.

7. Remove and destroy diseased young plants immediately, as they will remain unthrifty even if they survive. If spotted wilt develops after the fruit has formed destruction of diseased plants is of doubtful value especially when plants are few in number. In mid-summer plantings late affected plants frequently mature fruit (although this may be of inferior quality) when soil conditions are favourable.

FUSARIUM WILT OF TOMATOES.

Fusarium wilt of tomatoes is a fungus disease, which is present in practically all countries where tomatoes are grown. In this State the disease has been recorded from all the main tomato growing areas, and it ranks second in importance to spotted wilt; the economic losses caused have so far been far less serious, however, than those brought about by the latter disease.

Symptoms.

Usually the first visible symptom of Fusarium wilt is the yellowing of the lower leaves. These gradually turn brown and finally wither. At first these symptoms may be confined to a branch or two on one side of the plant only, but gradually the disease extends, killing the leaves successively from the base upwards, until the whole plant wilts and dies. (Plate 1.)

Plate 1.
Fusarium wilt. Diseased plant at right, healthy plant at left.
[After Humbert.]

If a branch on which the leaves have withered is cut open lengthways or pulled off at the fork in the stem, a brown discolouration of the water-conducting tissues can be noticed. (Plate 2.)

Plate 2.

Fusarium wilt. Stem portion split lengthways to show the brown discolouration of the water conducting tissues.

[After Bohn & Tucker.]

The disease may attack plants at any stage of growth, but it commonly appears first just as the fruits are ripening.

Cause of the Disease.

The fungus causing this disease (*Fusarium lycopersici* Sacc.) when once introduced into the soil may live on dead organic matter for many years. When susceptible tomato plants are grown the fungus may attack the roots especially through slight injuries and grow through them into the main stem. Here it develops mainly in the large water-conducting strands, and gradually spreads through them from the base towards the top of the plant.

As a result the upward flow of sap containing dissolved food materials is restricted so that finally the plant becomes unthrifty and wilts.

During wet weather plants killed by fusarium wilt frequently develop pink layers on their surfaces which consist of innumerable spores (fungal seeds) of the fungus. Unless such plants are removed the spores are widely disseminated to other parts of the field.

The disease is encouraged by relatively high temperatures, the optimum being about 85 deg. F., and under local conditions it is chiefly troublesome during the late spring and summer months.

There are several ways in which the disease may be introduced into new areas, the commonest being by means of infected seed or seedlings, or by contaminated animal manures. It may also be transported in soil attached to the roots of seedlings or adhering to farm implements, or carried by flood or irrigation waters.

Control.

As the organism responsible is a soil inhabitant and develops within affected plants it cannot be controlled by sprays. The following measures should be adopted as routine procedure in the commercial growing of tomatoes.

1. Carefully select fruit for seed from disease-free plants, or disinfect seed of doubtful origin or health.*

* Tomato seed may be disinfected by immersing and agitating in a one in three thousand solution of mercuric chloride (corrosive sublimate) for five minutes. The seed should then be washed for 15 minutes in clean running water and spread out thinly to dry in a cool shady place. The above solution may be prepared as follows:—Dissolve ½oz. of mercuric chloride in a quart of water; then take a ¼ pint of this stock solution and make up with water to 1 gallon 1⅜ pints.

Note —Mercuric chloride is poisonous. It will also corrode metals, hence only containers of glass, wood, earthenware or enamel may be used. Further details of seed and seedbed disinfection are obtainable in Department of Agriculture Leaflet No. 336.

2. Prepare fresh seed beds each year using either virgin or sterilised soil.†

3. Practise rotation of crops so that the land is cropped with tomatoes as infrequently as possible.

4. Do not feed infected plants to stock as the disease may be spread subsequently with the manure.

5. Remove and destroy diseased plants during the growing season, and when harvesting is over burn the crop remains. Also at this time sterilise the tomato stakes and seed-bed framework.

6. Resistant varieties are available for use on infected soil, but some of these are not as suitable as the commonly grown susceptible varieties. Also, probably owing to local variations in growing conditions and the occurrence of strains of the parasite which differ in virulence, varietal resistance may not be maintained in all areas. Growers should therefore test such varieties to decide which are most suitable. Varieties said to be resistant include:—

American: Marglobe, Potentate, Rutgers, Break o' Day, Marhio.

Australian: Australian Earliana, Early Dwarf Red.

BACTERIAL WILT OF TOMATOES.

Bacterial wilt of tomatoes is a serious disease which fortunately is so far of minor importance in W.A. when compared with either spotted or Fusarium wilt. The disease has only been found here in tomatoes and potatoes, but it can also attack many other plants, including:—Tobacco, eggplant, pepper, capsicum, black nightshade, thorn apple, peanut, and soybean. Although it was first recorded in this State many years ago, Bacterial wilt of tomatoes has since been noticed only infrequently from the Geraldton and metropolitan district.

Symptoms.

Usually the first symptom of the disease is the sudden wilting of the leaflets on an odd leaf or two, without any initial yellowing. This may occur at any part of the above ground portions of the plant, while the rest of the plant still looks quite healthy. If the attack is more severe the disease may first appear as a drooping or wilting of the whole plant.

Tomatoes affected with Bacterial wilt eventually die, but the foliage does not generally wither from below upwards as is generally the case with Fusarium wilt. The disease also produces a brown discoloration of the water-conducting tissues, and there is sometimes extensive destruction of the pith, leaving cavities in the stem. From the cut ends of stems or roots a greyish-white bacterial slime generally exudes, which characteristic helps to distinguish the disease from Fusarium wilt.

† Soil may be sterilised by steam, the most effective agent yet discovered, or by formalin. "To sterilise soil with formalin make up a 2 per cent. solution by adding one gallon of commercial formalin to 49 gallons of water. This solution is applied with a watering can to the soil which should previously have been well loosened up, at the rate of about one-half to one and one-half gallons of the solution to the square foot. The heavier the soil, the more needs to be used. The treated soil is then smoothed down and covered with bags moistened with the formalin solution, and left for several days. Forty-eight hours is usually enough, but no harm will be done if the covers are left on for a longer period. The bags are then removed and the soil thoroughly stirred with implements previously sterilised in steam, fire, boiling water, or formalin so as to let out the fumes. The stirring process should be repeated several times during the next ten days or a fortnight, after which the seeds may be safely sown." This treatment has been used a number of times in this State with great success.

Cause of the Disease.

The organism causing this disease (*Bacterium solanacearum*) is commonly spread to new areas by contaminated seed or soil. It attacks the roots of plants, especially through injuries, and gradually spreads through the water-conducting tissues. It may also be transmitted by chewing insects and by workers during pruning or other operations, and its spread in the field is generally attributed to these causes. The disease is encouraged by high temperatures, thriving best at about 95° F., and by wet weather; and it is generally said to be most serious in sandy soils.

The writer has had limited experience only of this disease locally and is anxious to obtain specimens. Recently cases were reported in which the disease appeared to be active at lower temperatures than usual. On potatoes the disease occurred on heavy soil and on tomatoes browning of the water-conducting tissues and bacterial slime production were inconspicuous. Possibly there are two rather similar diseases in W.A. or *B. solanacearum* may have slightly different environmental requirements.

Control.

The control measures for this disease are similar to those recommended for Fusarium wilt, but unfortunately resistant varieties are not available. In addition to these measures, however, chewing insects should be combated by either arsenate of lead containing dusts or sprays, and after handling diseased plants, workers' hands should be washed in warm soapy water.

Subterranean Clover Seed.

THE INFLUENCE OF SUPERPHOSPHATE ON GERMINATION.

G. R. W. MEADLY.

SUMMARY.

Literature pertaining to the effect of superphosphate on the viability of seeds is cited.

An experiment was conducted to test the germinating capacity of subterranean clover seed after having been in contact with both dry and moist super for varying periods of time. Both soil and blotting paper were used as germinating substrata and two different lines of superphosphates were involved.

With the soil tests, mixing with dry superphosphate did not affect the germination, even after seven days, but with moist superphosphate, although no decrease resulted after 24 hours, such was not the case after seven days. Although neither line affected the germination when dry, one had a greater harmful effect than the other when moist. This result was probably due, indirectly, to a higher initial moisture content of the more harmful line.

With the blotting paper tests there was no reduction in germination due to mixing with either sample of moist or dry superphosphate for 3-5 hours, or 24-26 hours. After several days, however, the moist and dry portions of both samples had caused a reduced germination. The degree of deterioration differed with the two samples and in each case a higher germination was secured with seed taken from the dry portion. The greater damage was caused again by the sample with the higher initial moisture content.

Providing the superphosphate is dry there is little or no risk due to contact between seed and super, even for a number of days. If the superphosphate is moist, however, the risk is increased appreciably, and contact for periods in excess of 24 hours should be avoided.

The effect of superphosphate on inoculating bacteria has been investigated by Cass Smith and Pittman (3). When it is desired to mix inoculated seed and superphosphate prior to sowing, both should be dry and sowing should take place into a thoroughly moist seed bed within half an hour of mixing.

INTRODUCTION.

Several papers have been written concerning the effect of superphosphate on the viability of seeds of various pasture species. Birks (2) showed that the vitality of rape seed was completely destroyed when seed was mixed with superphosphate and allowed to stand for periods varying from one to six days, the critical period depending upon the moisture content of the superphosphate. Seed sown with superphosphate in only partially moist sour soils also suffered serious adverse effects. Field results observed by Sherwin (5) in Tasmania indicated that a better stand of turnips was secured from two cwt. of basic superphosphate per acre prepared by mixing quantities of superphosphate and ground limestone than from 1 cwt. of superphosphate. In each case the seeds were mixed with the fertiliser before sowing and the improved crop was attributed to better seedling development. Whittet (6) found that superphosphate or sulphate of ammonia had practically no detrimental effect on white clover seed, even when in contact with it for seven days. Perennial rye grass seed was not affected by being mixed with the fertilisers for periods of four to 24 hours, but after being mixed with superphosphate for seven days, considerable reduction in viability resulted. Few viable seeds remained after 16 days. The germinating capacity of lucerne began to be detrimentally affected after being mixed with superphosphate for 36-48 hours. Ewart (4) stored dry wheat with an equal quantity of dry superphosphate for three to six weeks, but little or no injurious effect to the viability of the seed was indicated by germination tests. Adams (1) concluded from his experiments that leaving subterranean clover seed in superphosphate for 24 hours did not injure the seed, but a reduced germination resulted after nine days. He considered that some seeds of this species were easily damaged while others were very resistant. In 1938 the author conducted an exploratory experiment, mixing two lines of subterranean clover seed having a high and low hard seed content with standard and granular superphosphate, and basic superphosphate. The tests were not replicated, for which reason no figures are quoted, but no difference in germinating capacity was noted between controls and seeds removed from each fertiliser after 4 hours, 8 hours, 1, 2, 3, 7, and 14 days.

As mixing seed of subterranean clover with superphosphate before sowing is a common practice in this State, farmers have been enquiring recently concerning the effect of the superphosphate manufactured at the present time on the viability of the seed. Cass Smith and Pittman (3) have demonstrated clearly that the vitality of inoculating bacteria is impaired by mixing with superphosphate for periods as short as one hour, but no information was available concerning the effect of current lines of superphosphate on the actual seed viability.

EXPERIMENTAL PROCEDURE.

An experiment was designed to test the effect on the germinating capacity of mixing subterranean clover seed with moist and dry superphosphate for varying periods. Two different lines of superphosphate were used and the same procedure

was carried out for each: 100 grams were placed in flat porcelain dishes measuring 5in. x 5in; 10 mls. of water were added to half of these, and then 10 grams of subterranean clover seed was mixed thoroughly with the superphosphate in each dish. All were then covered with cardboard to prevent excessive evaporation from those which had been moistened.

As the removal and counting of the seeds occupy an appreciable period the time the seed remained mixed with the superphosphate is recorded as 3-5 hours, 24-26 hours, etc. One hundred and fifty seeds were removed from each tray during the times recorded, the removals being randomised to eliminate the time factor as far as possible. Three lots of fifty seeds from each dish were then placed on moist blotting paper in petri dishes and covered with bell jars. These were then placed in an incubator at 20° C. Particles of superphosphate adhering to a number of seeds taken from the moist superphosphate samples were not removed before placing them on the germinating substratum.

At the end of 24 hours a further series of seeds were removed and a germination test commenced on blotting paper. This was supplemented by a corresponding soil test, the soil being placed in petri dishes and covered with bell jars. A further double series was removed at the end of seven days. At this stage a small proportion of the seeds was enlarged and reddish, indicating water had been absorbed.

The soil tests at the end of one and seven days were included as the conditions for germination thus provided approximate more closely those experienced in the field than do blotting paper tests.

The following table gives the results of the various germination tests:—

Period in Super.	Substratum for Test.	Sample.	Superphosphate A. (moist) Germination.		Superphosphate A. (dry) Germination.		Superphosphate B. (moist) Germination.		Superphosphate B. (dry) Germination.	
			Sample Av.	Mean Av.	Sample Av.	Mean Av.	Sample. Av.	Mean Av.	Sample. Av.	Mean Av.
3-5 hours ...	Blotting paper	1	48		48		47		47	
Do. ...	do. do.	2	46	47 (94%)	48	48 (95%)	47	46 (93%)	48	48 (96%)
Do. ...	do. do.	3	48		46		46		49	
24-26 hours	Blotting paper	1	47		48		48		50	
Do. ...	do. do.	2	47	46 (93%)	46	47 (94%)	48	48 (96%)	49	49 (98%)
Do. ...	do. do.	3	45		47		47		49	
28-30 hours	Soil	1	46		48		47		48	
Do. ...	do.	2	46	46 (92%)	46	48 (96%)	46	47 (93%)	49	49 (97%)
Do. ...	do.	3	46		49		47		49	
7 days ...	Blotting Paper	1	34		37		36		42	
Do. ...	do. do.	2	25	31 (62%)	37	39 (78%)	36	33 (67%)	41	44 (87%)
Do. ...	do. do.	3	32		43		28		47	
7 days ...	Soil	1	40		47		43		48	
Do. ...	do.	2	37	39 (78%)	46	47 (94%)	42	44 (88%)	48	48 (97)%
Do. ...	do.	3	40		48		45		48	

Germination of original sample on blotting paper, av. 48 (96%).

ANALYSIS OF SUPERPHOSPHATE.

An analysis conducted by the Government Analyst defined the chemical composition of the two lines as follows:—

	A.	B.
	%	%
Total P_2O_5	18.47	21.78
Water soluble P_2O_5	16.33	19.31
Citrate soluble P_2O_5	1.18	1.55
Acid soluble P_2O_5	0.96	0.92
pH (glass electrode)	2.92	3.10
Moisture	3.5	1.6

RESULTS AND DISCUSSION.

In analysing the figures two separate experiments were considered, one in which the seeds were germinated on soil and the other in which blotting paper was the germinating substratum.

Experiment 1.—Soil substratum. The means were as follows:—

Separate Effects.

(a) Period of mixing with super—

28-30 hours	47
7 days	44

(b) Samples of super—

A.	45
B.	47

(c) Super (moist and dry)—

Moist	44
Dry	48

Interactions first order.

Period of mixing x samples—

	Period of Mixing.	
Sample	28-30 hours.	7 days.
A.	47	43
B.	48	46

Period of mixing x super, moist and dry—

	Period of Mixing.	
	28-30 hours.	7 days.
Moist	46	41
Dry	48	47

Samples x super (moist and dry)—

	Samples.	
	Super A.	Super B.
Moist	42	45
Dry	47	48

The main practical conclusions to be drawn from the figures are that mixing with dry superphosphate did not affect the germination even after seven days, but with moist superphosphate, although no decrease resulted after 24 hours, such was not the case after seven days. Although neither line affected the germination when dry, one had a greater harmful effect than the other when moist. As the line causing the greater damage had a higher initial moisture content (3.5 per cent. and 1.6 per cent.), the higher total moisture content may have been the influencing factor.

It is not suggested that the larger proportion of water directly caused the reduced germination, but rather that it dissolved and rendered active certain chemicals likely to prove injurious to the seed. Free sulphuric, hydrochloric and hydrofluoric acids are known to occur in superphosphate and although when in contact with subterranean clover seed for a short time they may actually stimulate germination by rendering the seed coat more permeable, if this period is extended, a stage may be reached when sufficient acid will be absorbed to weaken or even kill the embryo. The permeability of individual seed coats is variable as shown by "hard" and "semi-hard" seeds in standard germination tests and consequently the time which elapses before injury occurs is likely to be variable.

The experiment indicates, also, that an increase in the moisture content of superphosphate will induce increased absorption by the seeds and thus accentuate the damage caused by any injurious chemicals. Below a certain moisture level no absorption takes place or the intake is so slow that the seeds are not affected for an appreciable period. As the content rises above this critical level an increase in the rate of absorption must be expected along with a corresponding deterioration of the germinating capacity.

Experiment 2.—Blotting paper substratum. The means were as follows:—

Separate effects.

(a) Period of mixing with super—

3-5 hours	47
24-26 hours	48
7 days	36

(b) Samples of super—

A.	43
B.	45

(c) Super (moist and dry)—

Moist	42
Dry	46

Interaction first order.

Period of mixing x moist and dry—

	Period of Mixing. 3-5 hours.	24-26 hours.	7 days.
Moist ..	47	47	32
Dry ..	48	48	41

There was no reduction in germination due to mixing with either sample of moist or dry superphosphate for 3-5 hours or 24-26 hours. After seven days, however, the moist and dry portions of both samples had caused a reduced germination. The degree of deterioration differed with the two samples and in each case a higher germination was secured with seed taken from the dry portion. The greater damage was caused again by sample A. with the higher initial moisture content. No definite explanation can be advanced for the higher germinations secured on soil compared with blotting paper after seven days in contact with superphosphate. Seed taken from both wet and dry superphosphate reacted in the same way although the dry superphosphate caused less reduction in each case, in fact, as stated previously, when seed taken from it was tested on soil a normal germination resulted.

It is difficult to suggest an explanation for this result although the soil certainly would have a greater buffering effect than the blotting paper with a tendency to render inactive acids which may have been present on the surface or in the superficial layers of the seed at the time of removal from the superphosphate.

CONCLUSIONS.

When a small seeds attachment for the drill is not available, frequently subterranean clover seed is mixed with and sown along with the superphosphate. A question often asked by farmers, especially in recent months, is, "will mixing before sowing harm the seed?"

The results of this experiment have shown that providing the superphosphate is dry there is little or no risk due to contact between seed and superphosphate for a number of days. When the superphosphate is moist, however, the danger is increased. A ten per cent. added moisture content caused an appreciable reduction in viability after seven days, although there was no effect after 24 hours.

No difficulty should be experienced by farmers who mix their seed and superphosphate in the drill box itself, providing the drill is "run out" if not to be used for a few days. Even if other methods are adopted, damage to the germinating capacity of the seed can be obviated by mixing only the day's requirements each morning.

The above statements apply to the effect of superphosphate on the viability of subterranean clover seed. Its effect on inoculating bacteria has been investigated by Cass Smith and Pittman, who recommend that when it is desired to mix inoculated seed and superphosphate prior to sowing, both should be dry and sowing should take place into a thoroughly moist seed bed within half an hour of mixing. Leaflet No. 584 provides details of this aspect.

ACKNOWLEDGMENTS.

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Worms in Pigs.

C. R. TOOP, Senior Veterinary Surgeon.

The only internal parasite of economic importance occurring in pigs in Western Australia is the large roundworm—*Ascaris lumbricoides.* This parasite is widely distributed and occurs in most areas where pig raising is practised. Heavy infestations may be responsible for considerable economic loss. Young pigs are particularly susceptible and in consequence their development is severely retarded. Infested animals become stunted in growth and unthrifty in appearance. Mortality may occasionally occur amongst very young pigs.

The large round worm of the pig *Ascaris lumbricoides.*

These large worms occur in the small intestine. They are creamy white in colour, cylindrical in form and taper to a point at both ends. The average length is between six and 10 inches. Some may attain a length of 15 inches.

LIFE HISTORY.

The female worm is a prolific egg layer and may produce as many as 200,000 eggs daily. These are passed out with the droppings and contaminate the soil. In from 10 to 40 days or longer after reaching the exterior, the eggs develop to the infective stage when they are found to contain a larval parasite coiled up within the shell. These eggs are extremely resistant and may remain viable for several years. When, however, they are exposed to direct sunlight under hot, dry conditions they are unlikely to survive for more than a few weeks.

Infective eggs are swallowed with the food or water and in the case of young pigs may be picked up from the teats of the sow during feeding. Upon reaching the small intestine of the pig the eggs hatch, and the larvæ are set free. They burrow into the wall of the intestine and reach the blood vessels by which means they are carried to the liver and then via the heart to the lungs. Here they pass from the blood vessels to the alveoli or air sacs of the lung, and after undergoing further growth and development migrate up the trachea (windpipe), are swallowed, and pass down to the small intestine. Here they remain and grow to maturity.

SYMPTOMS.

The effects of the parasite are almost entirely confined to pigs under four months old. Although older animals may harbor the worms in quite considerable numbers they rarely suffer any ill effects.

In the case of young pigs growth is seriously impaired, and the animals become unprofitable. They remain stunted and unthrifty; the coat is rough and the animal has a pot-bellied appearance.

During their migration through the liver and lungs the larval worms inflict considerable injury which may prove fatal to young pigs during the first weeks of life. Pneumonia may develop as a sequel to the lung damage. In young pigs the invasion of the lungs by large numbers of larvæ may set up symptoms of laboured and forced respiration, this condition being commonly

known as "thumps." The development of pneumonia is denoted by the presence of a short hard cough which is particularly noticed after exertion. It must, however, be pointed out that the symptom of coughing so prevalent amongst young pigs is frequently due to infectious pneumonia and is not in any way related to the invasion of the lungs by ascarid larvæ.

Drenching a young pig.

DIAGNOSIS.

When the presence of roundworms is suspected the diagnosis may be confirmed by the slaughter and post mortem examination of an animal showing typical symptoms. The worms will be found in the small intestine or "runners" which extends from the stomach to the caecum or blind gut. This portion of the intestine should be freed from its attachments and opened with scissors. The parasites, when present, will not be overlooked on account of their large size. Occasionally worms which have wandered from their natural habitat in the small intestine may be found in the stomach or in the bile ducts of the liver.

Both the liver and lungs may show evidence of the injury inflicted by the larval worms during their migration. The surface of the liver may show the presence of whitish areas about ¼in. diameter. These are popularly known as milk

spots. The lungs may show more or less extensive solid pneumonic areas which contrast sharply with the spongy normal lung tissue which surrounds them.

When a post mortem examination cannot be performed a diagnosis can usually be established by the examination of a sample of the droppings in the laboratory for the presence of worm eggs.

TREATMENT.

There are two drugs which may be relied upon to expel roundworms from the small intestine of the pig. These are oil of chenopodium and phenothiazine. Other drugs which have from time to time been recommended have not given satisfactory results in our hands.

Oil of chenopodium should be given with or followed by a purgative such as castor oil.

The following mixture will be found satisfactory:—

Oil of chenopodium	1 fluid ounce.
Castor oil	25 fluid ounces.

The mixture should be administered at the rate of one fluid ounce per 25 lbs. of live weight. A single dose cannot be relied upon to remove all of the parasites and a second treatment should be given after an interval of 10 days has elapsed. The pigs should be starved for 24 hours before treatment. Pigs under the age of six weeks should not be treated. In general it will be found necessary to treat only weaners and slips. The drench may very conveniently be administered by means of a metal sheep drenching gun which may be set to deliver the required dose. During treatment young pigs may be held in an upright position with the buttocks resting on the ground between the knees of an assistant. Should the treatment of larger pigs become necessary these may be restrained by means of a running noose passing behind the tusks of the upper jaw and secured to a strong post.

Phenothiazine is a powdered drug which may be administered in the feed. The following dosage is advised:—

For pigs weighing 25 lbs.	1/6 ounce.
For pigs weighing 25-50 lbs.	1/4 ounce.
For pigs weighing 50-100 lbs.	1/2 ounce.
For pigs weighing 100-200 lbs.	3/4 ounce.
For pigs weighing over 200 lbs.	1 ounce.

Prior to treatment the pigs should be starved overnight and then graded according to their size. They should be treated in small groups which will ensure that each animal consumes an approximately equal share of the food material offered. According to the size and number of pigs in each group the required amount of the drug should be thoroughtly mixed in an amount of food which will readily be consumed. As an example weaners weighing 25 lbs. could be treated in groups of six, allowing each group one ounce of phenothiazine incorporated in the feed. Treatment should be repeated after an interval of 10 days. Pigs under six weeks old should not be treated.

Following the administration of phenothiazine red colored urine is excreted for a period of four or five days. This does not denote any interference with the health of the animal and need cause no concern.

PREVENTION AND CONTROL.

On old established piggeries the soil becomes heavily contaminated with worm eggs. Consequently the young pigs which are highly susceptible are exposed to infestation from the time of birth. While treatment will remove the adult worms from the intestine it can have no effect upon the larval parasites which seriously damage the lungs and liver during their migration. It, therefore, becomes necessary to adopt preventive measures. Good sanitation, including the drainage of yards with the object of keeping them dry, the daily removal of droppings, the provision of sties with concrete floors and of troughs which will prevent the animals feeding off the ground will assist in limiting the degree of infestation. Much better results will, however, be obtained if it is possible to completely protect the young pigs from infestation. The MacLean County system which has been extensively and successfully practised in the United States has this object in view. Its purpose is to prevent the exposure of the young pigs to infection from the time of birth until they are four or five months old.

The following procedure is adopted:—

Farrowing pens with concrete floors are provided. A few days before farrowing is due to occur the floor and walls are thoroughly cleansed by washing with a boiling 5% Kerol solution (8 ounces to the gallon of water) applied with a hard broom. Immediately before being placed in the farrowing pen the sow is washed with a warm solution of soap and water, all mud and litter being removed, particular attention being paid to the cleansing of the udder and teats. This will remove any worm eggs which may be adhering to the body of the animal. Within 10 days of farrowing the sow and her litter are carted to a clean field or a field which has been sown with a green crop and has not been occupied by pigs within the past year. The matter may be placed on a very satisfactory basis if three pig paddocks can be made available and used in annual rotation. The paddock intended for the reception of sows and their litters should be cultivated and sown with a suitable green crop, the other two paddocks remaining vacant. On this basis each of the paddocks will be used every third year and will remain unoccupied during the remaining two years, when it may be used for the production of other farm crops. Under such a system of rotation and cultivation few worm eggs will remain viable and the young pigs may be carried to the age of four or five months without becoming seriously affected. Thereafter the animals, which are no longer highly susceptible, may be transferred to the old yards or sties for fattening purposes.

Pig Feeding Trial at Muresk Agricultural College.

DEMONSTRATION IN THE USE OF MEAT MEAL AS A SUPPLEMENT TO WHEAT.

M. Cullity, Superintendent of Dairying.

C. R. Dixon, Pig Husbandryman.

The possibility of increasing the number of bacon pigs which are produced in the wheatgrowing districts has been discussed on many occasions. It has been suggested that by giving more attention to pig raising farmers could ease the marketing difficulties associated with the surplus production of wheat and add some security to their operations. While the fallacy of feeding wheat alone is known to most farmers, there is apparently a large number who do not understand how wheat may be used with proper supplements in order to obtain rapid and economical growth.

The report of Hughes and Dixon showed that the use with wheat of a protein supplement—such as skim milk or meatmeal—was necessary for feeding bacon pigs. However, at the present time meatmeal is not plentiful and it is desired that the available supplies should be used to the greatest advantage.

The present trial may be considered exploratory in an endeavour to determine whether the proportion of meatmeal fed in the earlier experiment could be reduced without affecting adversely the profit from the pig or the quality of its carcass.

Twenty-four pigs were selected from the litters of one Berkshire and two Tamworth sows, which had been mated to a Berkshire boar.

From the date of mating until a few days before farrowing, the sows were run in paddocks where green grazing was available.

A few days prior to farrowing they were brought into the pens and remained there for one week after the litters were born, when they were moved to small yards until the piglets were one month old.

The sows and litters then were put into paddocks of green oats and capeweed until the date of weaning.

As the young pigs were weaned, they were divided as evenly as possible according to weight into four groups, there being two pigs from each litter in each group.

From the commencement of the trial each group was fed separately as much as the pigs would consume in two periods each of twenty minutes. Water was available at all times.

The ration for each group was varied as follows:—

Group 1.—Mixture of wheat and meatmeal in a ratio of 2 : 1 for the first week; thereafter the proportion of meatmeal was gradually reduced until the final week when the ratio was 10 : 1.

Group 2.—A mixture of wheat and meatmeal in a ratio of 9 : 1 for four weeks, the meatmeal then being reduced to 16 : 1 for the fifth week, and thereafter until the end of the trial the meatmeal was further reduced to a ratio of 24 : 1.

Group 3.—A mixture of wheat and meatmeal in the ratio of 9 : 1 for four weeks after the commencement of the trial: from that time until the end of the experiment this group received wheat only.

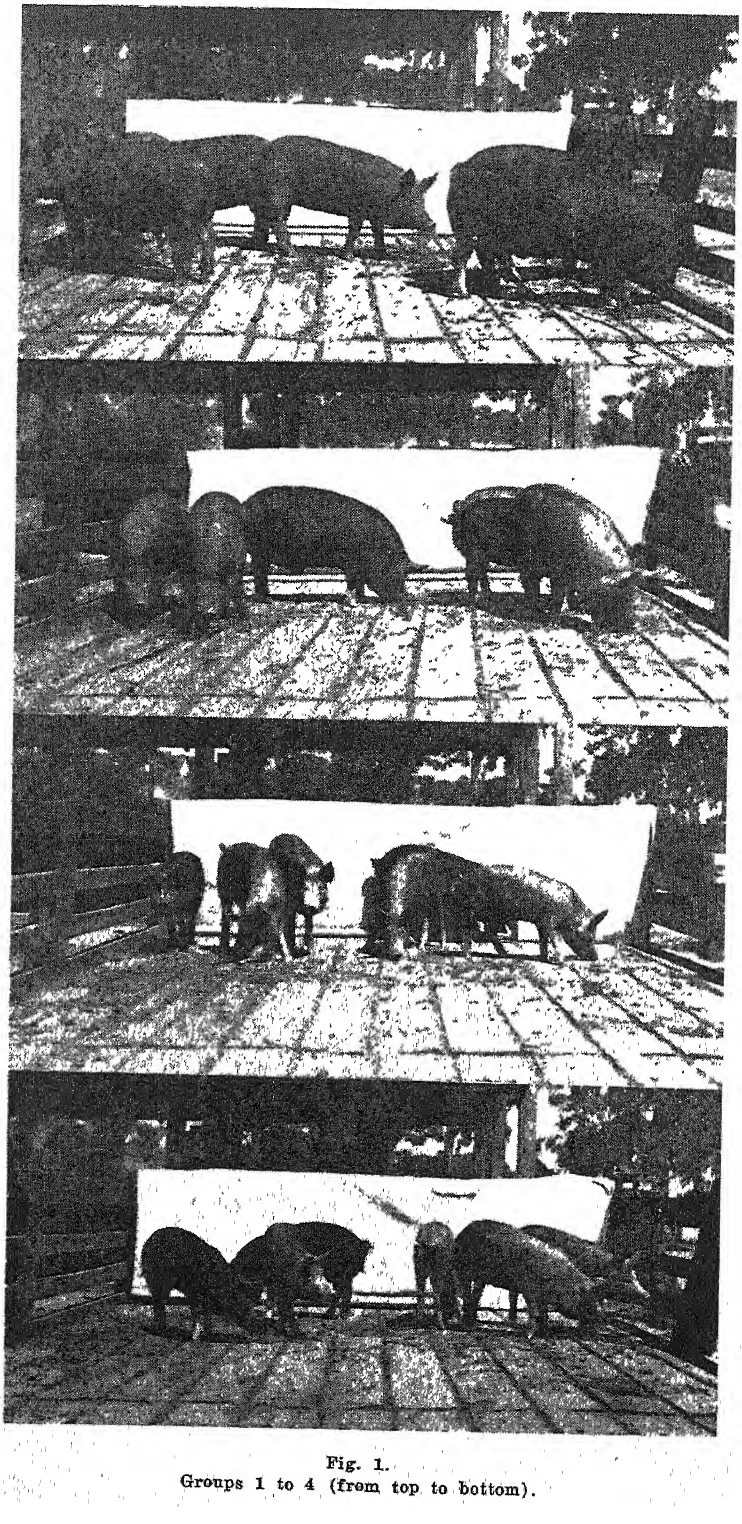


Fig. 1.
Groups 1 to 4 (from top to bottom).

Group 4.—Wheat only.

The composition of the wheat and meatmeal was determined in the Government Chemical Laboratory as follows:—

Wheat—Water, 5.78; ash, 14.03; ether extract, 22.32; fibre, 2.88; protein, 52.88

Meatmeal—Water, 10.23; ash, 1.91; ether extract, 2.94; fibre, 3.56; protein, 11.6.

The percentage of protein in the rations of the various groups is given hereunder:—

Group 1.—25.3 per cent. at the start, then reduced gradually throughout the trial to 15.3 per cent.

Group 2.—15.7 per cent. for the first four weeks, 14.0 per cent. for the fifth week, and thereafter 13.2 per cent.

Group 3.—15.7 per cent. for the first four weeks, thereafter 11.6 per cent.

Group 4.—11.6 per cent.

A mineral supplement (Di-calcic Lick) was included in the ration of each group and comprised 2½ per cent. of the total ration.

Greater quantities of food were consumed as the pigs grew, and, owing to the greater rapidity of growth of Groups 1 and 2, their requirements of food became proportionately greater until at the end of the trial they were consuming slightly more than twice the amount used by Groups 3 and 4. The actual quantities consumed by each group are shown in Table 5.

WEIGHTS OF INDIVIDUAL PIGS IN EACH GROUP.

TABLE 1.

GROUP 1.

Ration, Crushed Wheat and Meatmeal. (For details see Table 5.)

Weight Week ending.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	Average.	Average Gain.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
8th September ...	49	33	42	48	38	41	41·83	...
15th September ...	49	36	40	47	42	43	42·83	1·0
22nd September ...	55	42	44	50	43	50	47·33	4·5
29th September ...	61	46	46	55	47	54	51·5	4·16
6th October	69	56	58	64	57	68	62·0	10·5
13th October ...	74	60	65	67	61	78	67·5	5·5
20th October ...	82	70	70	74	68	84	74·66	7·16
27th October ...	90	77	76	83	77	93	83·0	8·33
3rd November ...	99	90	88	92	85	107	93·5	10·5
10th November ...	109	99	99	103	98	116	104·0	10·5
17th November ...	118	107	104	109	104	120	110·33	6·33
24th November ...	126	116	112	121	110	134	119·83	9·5
1st December ...	137	121	120	126	120	145	128·16	8·33
8th December ...	143	137	135	141	128	160	140·66	12·5
15th December ...	154	146	142	152	136	167	149·5	8·83
22nd December ...	166	158	155	164	147	177	161·16	11·66
29th December ...	181	166	169	170	160	190	172·66	11·5
5th January ...	194	176	177	180	168	204	183·16	10·5
12th January ...	199	186	190	190	178	219	193·66	10·5

WEIGHTS OF INDIVIDUAL PIGS IN EACH GROUP—*continued.*

TABLE 2.

GROUP 2.

Ration, Crushed Wheat and Meatmeal. (For details see Table 5.)

Weight Week ending.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	Average.	Average Gain.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
8th September ...	41	40	41	38	38	50	41·33	...
15th September ...	41	40	39	37	38	50	40·83	·5
22nd September ...	45	45	43	42	42	55	45·33	4·5
29th September ...	47	48	46	45	46	56	48·0	2·66
6th October	56	59	55	54	54	64	57·0	9·0
13th October ...	58	66	60	63	60	69	62·66	5·66
20th October ...	66	73	67	64	58	75	67·16	4·5
27th October ...	77	85	77	67	60	89	75·83	8·66
3rd November ...	84	93	83	72	57	96	80·83	5·0
10th November ...	94	104	93	81	61	107	90·0	9·16
17th November ...	97	108	95	87	61	108	92·66	2·66
24th November ...	105	117	103	97	70	121	102·16	9·5
1st December ...	114	128	113	105	76	127	110·5	8·33
8th December ...	123	140	123	116	83	137	120·33	9·83
15th December ...	126	146	133	127	90	149	128·5	8·16
22nd December ...	133	154	142	138	94	159	136·66	8·16
29th December ...	141	164	150	153	100	170	146·33	9·66
5th January ...	149	176	161	162	112	176	156·0	9·66
12th January ...	156	181	171	173	117	194	165·33	9·33

TABLE 3.

GROUP 3.

Ration, Crushed Wheat with addition of Meatmeal for one month only. (For details see Table 5.)

Weight Week ending.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	Average.	Average Gain.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
8th September ...	45	41	36	42	41	42	41·16	...
15th September ...	45	41	34	39	41	41	40·16	1·0
22nd September ...	49	44	37	42	44	45	43·5	3·33
29th September ...	56	50	43	43	49	49	48·83	4·83
6th October	66	59	50	48	57	56	56·0	7·66
13th October ...	69	61	50	48	57	59	57·33	1·33
20th October ...	72	63	52	47	60	60	59·0	1·66
27th October ...	79	69	56	52	67	66	64·83	5·83
3rd November ...	85	71	59	52	68	69	67·33	2·50
10th November ...	89	75	60	52	72	72	70·0	2·66
17th November ...	98	82	64	55	77	78	75·66	5·66
24th November ...	102	82	60	53	78	79	75·66	...
1st December ...	104	85	65	54	84	85	79·5	3·83
8th December ...	110	85	64	53	83	84	79·83	·33
15th December ...	114	94	69	58	88	92	85·83	6·0
22nd December ...	120	99	69	55	92	93	88·0	2·16
29th December ...	124	102	60	60	97	96	89·83	1·83
5th January ...	129	107	71	60	102	102	95·16	5·33
12th January ...	133	109	72	60	104	104	97·0	1·83

WEIGHTS OF INDIVIDUAL PIGS IN EACH GROUP—*continued.*

TABLE 4.

GROUP 4.

Ration, Wheat only. (For details see Table 5.)

Weight Week ending.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	Average.	Average Gain.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
8th September ...	43	38	43	44	40	41	40·5	...
15th September ...	42	37	39	43	39	41	40·16	·33
22nd September ...	44	39	39	48	41	43	42·33	2·16
29th September ...	46	41	42	51	43	45	44·66	2·33
6th October	51	45	48	57	47	52	50·0	5·33
13th October ...	52	47	51	61	50	54	52·5	2·5
20th October ...	54	48	53	65	51	58	54·83	2·33
27th October ...	58	50	58	68	54	64	58·66	3·83
3rd November ...	58	50	60	72	54	67	60·16	1·5
10th November ...	60	52	63	74	57	74	63·33	3·16
17th November ...	64	56	68	80	60	79	67·83	4·5
24th November ...	63	52	67	83	58	81	67·33	·5
1st December ...	63	53	69	81	59	83	68·0	·66
8th December ...	63	53	70	82	65	87	70·0	2·0
15th December ...	66	57	75	88	64	91	73·5	3·5
22nd December ...	66	56	76	89	62	93	73·66	·16
29th December ...	66	57	76	91	64	966	75·0	1·33
5th January ...	70	60	81	95	66	104	79·33	4·33
12th January ...	70	60	81	96	66	106	79·83	·5

TABLE 5.

RATIONS FED TO PIGS IN EACH GROUP.

Date.	GROUP 1. Per Pig per Day.		GROUP 2. Per Pig per Day.		GROUP 3. Per Pig per Day.		GROUP 4. Per Pig per Day.
	Grain.	Meat-meal.	Grain. (9 parts)	Meat-meal. (1 part)	Grain. (9 parts)	Meat-meal. (1 part)	Grain only.
Week ending—							
15th September ...	½ lb.	¼ lb.	¾ lb.	mixture	¾ lb.	mixture	¾ lb.
22nd September ...	1 lb.	½ lb.	1½ lbs.	,,	1½ lbs.	,,	1½ lbs.
29th September ...	1½ lbs.	½ lb.	2 lbs.	,,	2 lbs.	,,	1½ lbs.
6th October ...	2 lbs.	½ lb.	2½ lbs.	,,	2½ lbs.	,,	1¾ lbs.
			(16 parts)	(1part)	Grain only.		
13th October ...	2½ lbs.	½ lb.	3 lbs.	mixture	2¼ lbs.		1¾ lbs.
			(24 parts)	(1 part)			
20th October ...	2½ lbs.	½ lb.	3 lbs.	mixture	2¼ lbs.		2 lbs.
27th October ...	3 lbs.	½ lb.	3½ lbs.	,,	2¼ lbs.		2 lbs.
3rd November ...	3 lbs.	½ lb.	3½ lbs.	,,	2¼ lbs.		2 lbs.
10th November ...	3½ lbs.	½ lb.	4 lbs.	,,	2½ lbs.		2¼ lbs.
17th November ...	3½ lbs.	½ lb.	4 lbs.	,,	2½ lbs.		2¼ lbs.
24th November ...	4 lbs.	½ lb.	4½ lbs.	,,	2½ lbs.		2¼ lbs.
1st December ...	4 lbs.	½ lb.	4½ lbs.	,,	2½ lbs.		2½ lbs.
8th December ...	4½ lbs.	½ lb.	5 lbs.	,,	2½ lbs.		2½ lbs.
15th December ...	4½ lbs.	½ lb.	5 lbs.	,,	2½ lbs.		2½ lbs.
22nd December ...	4¾ lbs.	½ lb.	5¼ lbs.	,,	2½ lbs.		2½ lbs.
29th December ...	4¾ lbs.	½ lb.	5¼ lbs.	,,	2¾ lbs.		2½ lbs.
5th January ...	4¾ lbs.	½ lb.	5¼ lbs.	,,	2¾ lbs.		2½ lbs.
12th January ...	5 lbs.	½ lb.	5½ lbs.	,,	2¾ lbs.		2½ lbs.

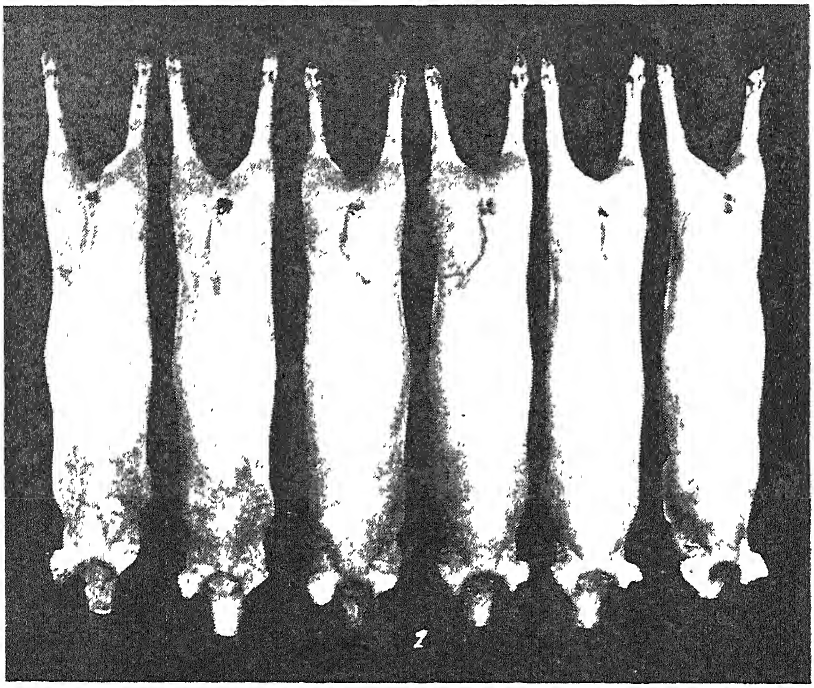


Fig. 2. Group 1.

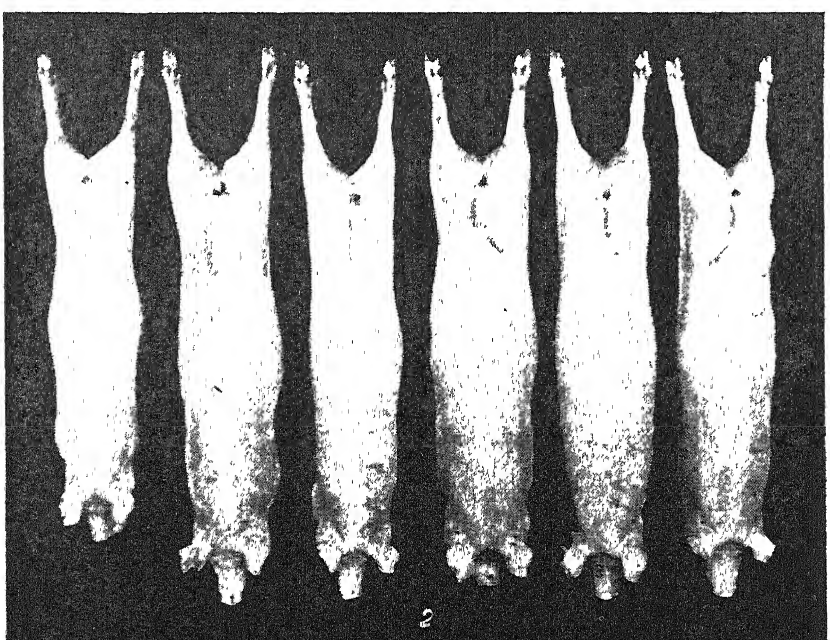


Fig 3 Group 2.

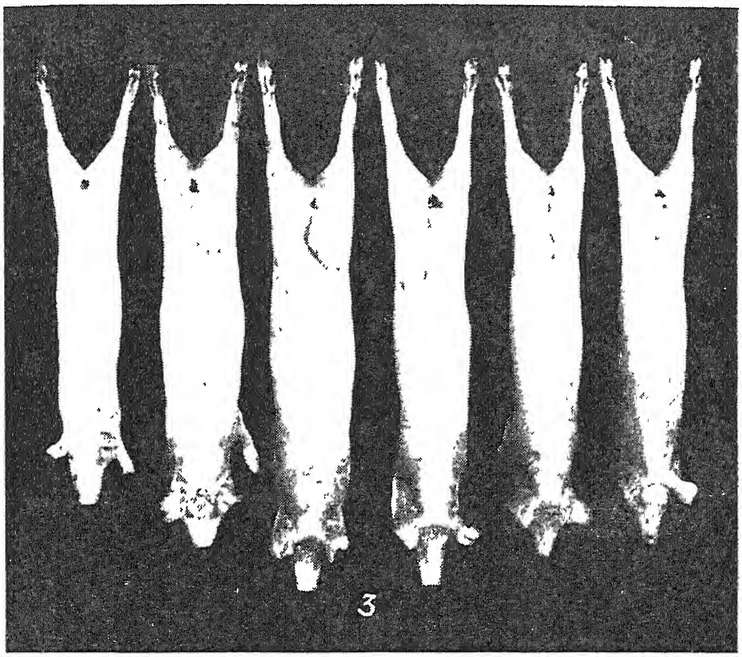


Fig. 4. Group 3.

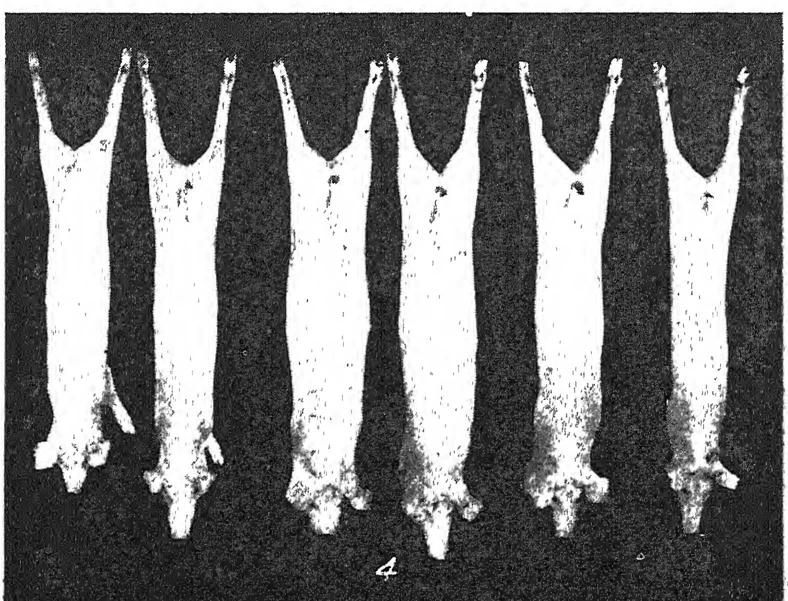
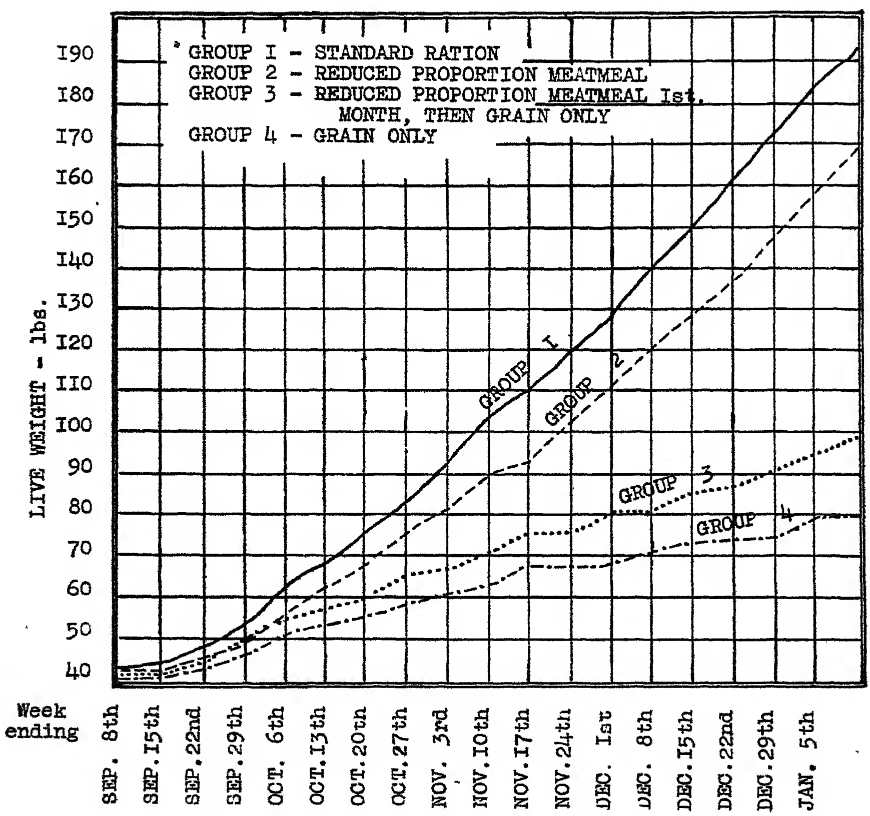


Fig. 5. Group 4.

All the pigs were weighed at weekly intervals, and the details of their weights are shown in Tables 1, 2, 3, and 4.

At the commencement of the trial the average weights of the pigs in the various groups were very even, but as feeding progressed differences in the rate of gain were noticed quickly, and it was obvious that Group 4, receiving no meatmeal were not as thrifty as the animals in the other pens. After the lapse of two months, a slight unthriftiness became discernible in the animals of Group 3 which had received meatmeal for the first month only.

The comparative rates of growth are shown in the accompanying graph.



CURVES OF WEIGHT INCREASES.

A study of this graph shows several interesting features.

The rate of growth of Group 1 receiving the greatest amount of protein was the most rapid of all the groups, while the inclusion of only one part of meatmeal in 24 parts of wheat—giving a mixture having 13.2 per cent. of protein—was responsible for markedly superior growth than where wheat alone was fed, while the group receiving this ration was definitely inferior to Group 1. In Group 3 is noticed probably the most interesting features. While the wheat-meatmeal mixture was being fed, the rate of growth was almost equal to that of Group 1, but as soon as the feeding of this supplement ceased, the rate of growth slowed down markedly and the average weights quickly fell below that of Group 2.

It should be noted that the quantity of meatmeal fed in the first month to Group 3 was the same as that fed to Group 2, but considerably less than that used in the ration for Group 1.

It was intended originally that all pigs should be slaughtered when the average weight of group 1 was approximately 120 lbs. dead weight. However, owing to unforeseen difficulties it was not possible to send the pigs to the treatment works for almost three weeks after this weight had been reached.

All pigs were forwarded to the Watsonia Bacon Factory on 11th January and were slaughtered on 13th January. The difference in the live weights as despatched from the College and their dead weights (cold) is given hereunder, together with a record of their grading for disposal, the prices paid and their value.

TABLE 6

Group No.	No. of Pigs in Group.	Live Weight.	Dressed Weight.	Grading.	Price	Value.
		lbs.	lbs.		per lb.	£ s. d.
1	1	199	151	1st Wiltshire	6¾d.	4 4 11
	2	186	139	do.	6¾d.	3 18 2
	3	190	141	1st Bacon	7½d.	4 8 2
	4	190	140	do.	7½d.	4 7 6
	5	178	130	do.	7½d.	4 1 3
	6	219	161	1st Wiltshire	6¾d.	4 10 7
						£25 10 7
Average Dressing Percentage—74·2 per cent.						
2	1	156	116	1st Wiltshire	6¾d.	3 5 3
	2	181	139	do.	6¾d.	3 18 2
	3	171	127	do.	6¾d.	3 11 5
	4	173	128 { 64	do.	6¾d.	3 6 8
			64	One side reject	5¾d.	
	5	117	86	1st Bacon	7½d.	2 13 9
	6	194	149	1st Wiltshire	6¾d.	4 3 10
						£20 19 1
Average Dressing Percentage—75·1 per cent.						
3	1	133	99	1st Bacon lowest range ...	7½d.	3 1 11
	2	109	84	do. do. ...	7½d.	2 12 6
	3	72	55	1st Pork storage Darwin pork	7½d.	1 14 5
	4	60	43	do. do. do.	7½d.	1 6 10
	5	104	79	1st Bacon lowest range ...	7½d	2 9 4
	6	104	77	do. do. .	7½d	2 8 2
						£13 13 2
Average Dressing Percentage—75·1 per cent.						
4	1	70	53	1st Pork storage Darwin pork	7½d.	1 13 2
	2	60	41	do. do. ..	7½d.	1 5 7
	3	81	60 { 30	1st Bacon lowest range ...	7½d.	1 17 6
			30	Darwin pork	7½d	
	4	96	73	1st Pork storage Darwin pork	7½d.	2 5 8
	5	66	49	do. do. ...	7½d	1 10 7
	6	106	81	1st Bacon lowest range ...	7½d	2 10 8
						£11 3 2
Average Dressing Percentage—74·5 per cent.						

A record of the cost of the foodstuffs used was kept, and thus it has been possible to compare the profit over the cost of feed for each group.

TABLE 7.

PROFIT OVER COST OF FEED.

Group No.	Value of Pigs.	Cost of Feed.	Margin—Value over Cost of Feed.
	£ s. d.	£ s. d.	£ s. d.
Group 1	25 10 7	9 2 0	16 8 7
Group 2	20 19 1	8 17 2	12 1 7
Group 3	13 13 2	5 6 1	8 7 1
Group 4	11 3 2	4 8 0	6 15 1

Further details showing the average weight increase for each pig, the quantity of grain and meatmeal consumed during the trial and also calculated per pound of live weight increase, together with the cost of feed per pound of live weight increase are given in Table 8.

TABLE 8.

——	Group 1.	Group 2.	Group 3.	Group 4.
Average weight at weaning (lbs.)	41·8	41·3	41·2	40·5
Average weight at end of trial (lbs.) ...	193·7	165·3	97·0	79·8
Average gain per pig (lbs.)	151·9	124·0	55·8	39·3
Amount crushed wheat consumed per pig (lbs.)	414·7	453·8	285·8	262·5
Amount meatmeal consumed per pig (lbs.) ...	61·2	22·2	4·7	...
Weight of feed per pound live weight increase (lbs.)	3·1	3·8	5·2	6·6
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total cost of feed per pig	1 10 4	1 9 6	0 17 8	0 14 8
Average cost per pound live weight increase (pence)	2·4	2·8	3·9	4·4

Photographs of the live pigs and of the carcases are shown in Figures 1 to 8.

The carcasses selected for Figures 6, 7, and 8 were those which approached most nearly to the average weight of each group. When the carcasses were cut down, measurements of the length of the sides, the width of the eye muscle, and the depth of the backfat were made and are shown in Table 9 together with an external measurement of all carcasses from the poll to the butt of the tail.

Discussion.

The evidence which has been obtained confirms the previous conclusions that meatmeal can be used successfully as a supplement to wheat. The rates of growth and development of groups 1 and 4, those receiving an ample supply of meatmeal and those receiving wheat only, are so widely different that if there was no other data available only one conclusion could be drawn, that the feeding of wheat alone is a most unprofitable method of feeding pigs.

Of the three groups receiving meatmeal, group 1 made the most rapid growth, produced the best carcasses and returned the greatest profit over the cost of feed: group 2, which received a reduced proportion of meatmeal throughout the trial, made relatively rapid growth, but not quite so rapid as group 1.

TABLE 9.

Group No.	Pen.	Dead Weight. (Average —Cold)	Tail Butt to Poll. (Average)	Length Aitch-bone to Symphysis 1st Rib and Sternum.	Aitchbone to Toe.	Depth Eye Muscle.	Back Fat.
		lbs.	inches.	mm.	mm.	mm.	mm.
1	1	161	42				
	2	139	39				
	3	141	39				
	4	140	39	719	550	43	32
	5	130	40				
	6	151	40				
	Average	144⅓	39⅚				
2	1	149	40				
	2	127	38				
	3	86	35				
	4	116	38	700	537	32	42
	5	128	38				
	6	139	39				
	Average	124½	38				
3	1	99	37				
	2	55	32				
	3	84	35				
	4	79	34	625	462	31	24
	5	77	33				
	6	43	27				
	Average	73	33				
4	1	53	32				
	2	41	29				
	3	60	32				
	4	73	33	575	488	26	19
	5	49	31				
	6	81	33				
	Average	59⅔	31⅔				

The quantity of food consumed per pound of live weight gain was the lowest in group 1, 3.1 lbs. of the ration mixture being required for each pound increase in weight. It will be noticed that the utilisation of food by groups 3 and 4 was particularly poor. The pigs in group 3 grew more rapidly for the first month than those in group 4, due to the inclusion of some meatmeal in their ration during that period. Being larger in size at the end of the month, their requirement for food was proportionately greater, while the rate of increase in weight from that time on to the end of the trial was no faster.

The total cost of feeding each pig was greatest in group 1 and the lowest in group 4, but owing to the greater rapidity of growth in the former group, the cost of food per pound of live weight increase, was lower than in the other groups. The cost of feed for each pound of gain increased as the proportion of meatmeal was reduced and was highest where wheat only was used.

It is therefore apparent that under conditions similar to those in the wheatbelt, the provision of meatmeal is not an added expense in feeding pigs, but is actually a means of reducing costs of production.

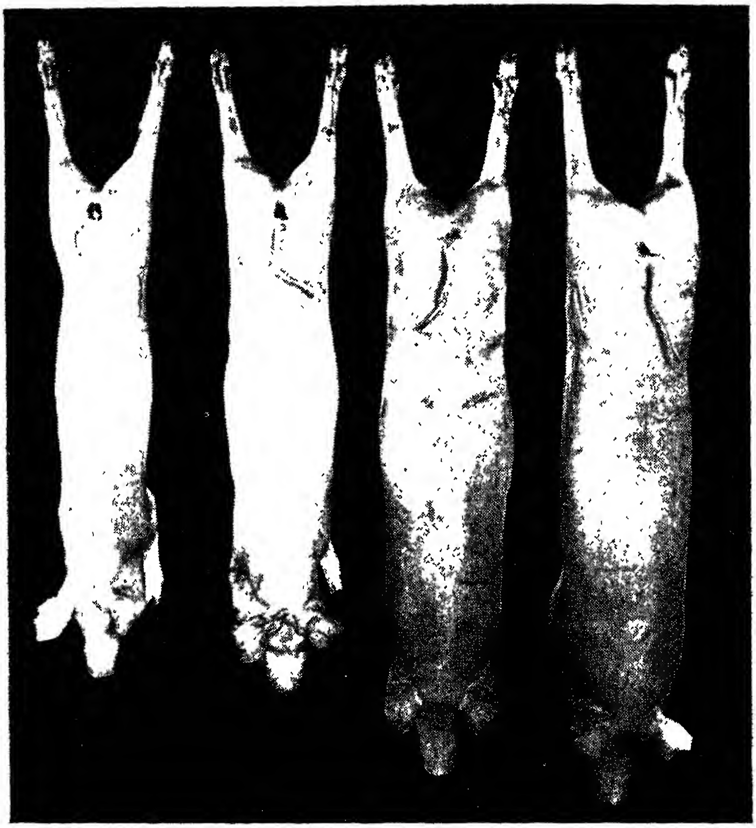


Fig. 6.
An average carcass from each group. Groups 1 to 4 from right to left.

In an earlier trial at the Muresk Agricultural College (Hughes and Dixon) where no protein supplement was used in the grain allowance, only 3.93 lbs. of wheat were required to produce one pound of live weight gain, whereas in the present trial 6.6 lbs. of grain were needed. In the earlier trial, however, a quantity of green fodder, principally lucerne, was allowed to all pigs daily. This, no doubt, was largely responsible for the better utilisation of the wheat.

On slaughter there was no significant difference in the dressing percentage of the various groups.

The quality of the carcasses of group 2 were found to be generally inferior to those of group 1—see Table 6. Three of the six carcasses of the latter group were considered suitable as first grade for the local bacon trade and the other three were suitable for the export trade as first grade Wiltshire sides and one only (a light carcass) as fit for the local trade. It is explained that on a perusal of weight alone it might be considered that group 2, averaging 124½ lbs. per carcass, would be generally more suitable for the local trade than group 1, which averaged 144½ lbs. per carcass—as normally it is the heavier and usually fatter pigs which are exported, while the lighter, less fat pigs are retained for the local market. In this trial, however, the heavier pigs of group 1 were considered more suitable for the local trade than the lighter pigs of group 2. This classification was due to the relatively fatter condition of the carcasses of this latter group.

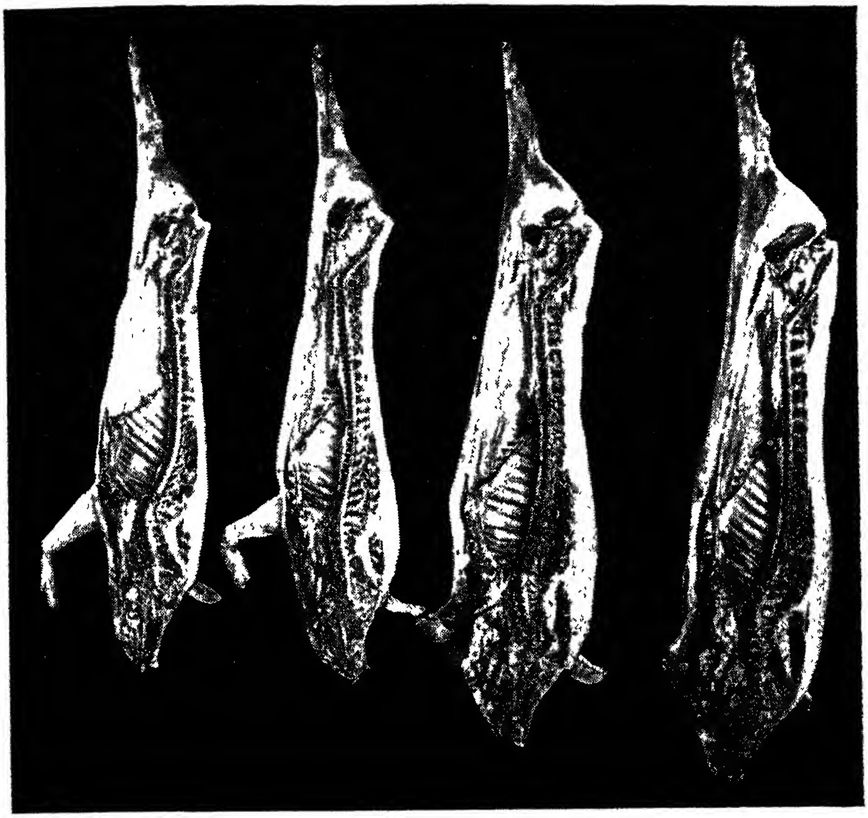


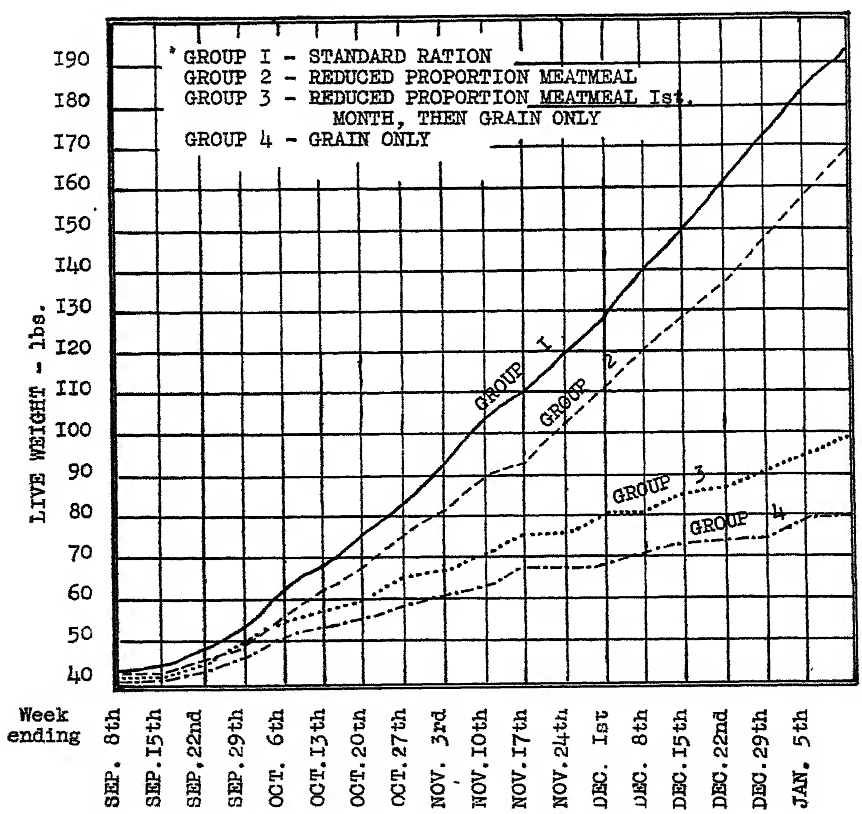
Fig. 7.
The carcasses in Fig. 5 were cut down. The sides are Groups 1 to 4 from right to left.

Although it was not possible to cut down each carcass for measurement, the details of the representative carcasses shown in Table 9 are interesting. The carcass nearest the average weight of each group was cut down into sides and again through the loin to enable photographs to be taken. Measurements of these sides indicated that the side from group 1 was considerably longer (19 m.m. or nearly 4/5ths of an inch) than that representing group 2. That this is probably a true index of the average for the whole of the groups is supported by the external measurements from poll to the base of the tail, which showed the pigs of group 1 to be 1-5/6ths inches longer than those of group 2. This comparison may be seen in Figures 6, 7, and 8, showing the carcasses, the sides and cuts through the loin of the four representative carcasses. It will be noticed that the depth of back fat in the sides is greatest in that from group 2, while the width of the eye muscle in the loin cuts is greatest in that representing group 1. From Table 9 it may be seen also that the respective depths of back fat in groups 1 and 2 are 32 m.m. and 42 m.m. respectively, the eye muscle measurements were 43 m.m. and 32 m.m. respectively. It appears reasonably conclusive, therefore, that the proportion of meatmeal fed to group 2 has not provided so satisfactory a result as that fed to group 1, and that if the proportion fed to group 1 is higher than necessary the amount of meatmeal fed cannot be reduced to the level of that fed to group 2 without affecting the rate of growth, the quality of the carcass and the profit.

All the pigs were weighed at weekly intervals, and the details of their weights are shown in Tables 1, 2, 3, and 4.

At the commencement of the trial the average weights of the pigs in the various groups were very even, but as feeding progressed differences in the rate of gain were noticed quickly, and it was obvious that Group 4, receiving no meatmeal were not as thrifty as the animals in the other pens. After the lapse of two months, a slight unthriftiness became discernible in the animals of Group 3 which had received meatmeal for the first month only.

The comparative rates of growth are shown in the accompanying graph.



CURVES OF WEIGHT INCREASES.

A study of this graph shows several interesting features.

The rate of growth of Group 1 receiving the greatest amount of protein was the most rapid of all the groups, while the inclusion of only one part of meatmeal in 24 parts of wheat—giving a mixture having 13.2 per cent. of protein—was responsible for markedly superior growth than where wheat alone was fed, while the group receiving this ration was definitely inferior to Group 1. In Group 3 is noticed probably the most interesting features. While the wheat-meatmeal mixture was being fed, the rate of growth was almost equal to that of Group 1, but as soon as the feeding of this supplement ceased, the rate of growth slowed down markedly and the average weights quickly fell below that of Group 2.

It should be noted that the quantity of meatmeal fed in the first month to Group 3 was the same as that fed to Group 2, but considerably less than that used in the ration for Group 1.

It was intended originally that all pigs should be slaughtered when the average weight of group 1 was approximately 120 lbs. dead weight. However, owing to unforeseen difficulties it was not possible to send the pigs to the treatment works for almost three weeks after this weight had been reached.

All pigs were forwarded to the Watsonia Bacon Factory on 11th January and were slaughtered on 13th January. The difference in the live weights as despatched from the College and their dead weights (cold) is given hereunder, together with a record of their grading for disposal, the prices paid and their value.

TABLE 6

Group No.	No. of Pigs in Group.	Live Weight.	Dressed Weight.	Grading.	Price	Value.
		lbs.	lbs.		per lb.	£ s. d.
1	1	199	151	1st Wiltshire	6¾d.	4 4 11
	2	186	139	do.	6¾d.	3 18 2
	3	190	141	1st Bacon	7½d.	4 8 2
	4	190	140	do.	7½d.	4 7 6
	5	178	130	do.	7½d.	4 1 3
	6	219	161	1st Wiltshire	6¾d.	4 10 7
						£25 10 7
Average Dressing Percentage—74·2 per cent.						
2	1	156	116	1st Wiltshire	6¾d.	3 5 3
	2	181	139	do.	6¾d.	3 18 2
	3	171	127	do.	6¾d.	3 11 5
	4	173	128 {64 64	do. ... ... One side reject	6¾d. 5¾d.	3 6 8
	5	117	86	1st Bacon	7½d.	2 13 9
	6	194	149	1st Wiltshire	6¾d.	4 3 10
						£20 19 1
Average Dressing Percentage—75·1 per cent.						
3	1	133	99	1st Bacon lowest range ...	7½d.	3 1 11
	2	109	84	do. do. ...	7½d.	2 12 6
	3	72	55	1st Pork storage Darwin pork	7½d.	1 14 5
	4	60	43	do. do. do.	7½d.	1 6 10
	5	104	79	1st Bacon lowest range ..	7½d	2 9 4
	6	104	77	do. do. .	7½d	2 8 2
						£13 13 2
Average Dressing Percentage—75·1 per cent.						
4	1	70	53	1st Pork storage Darwin pork	7½d.	1 13 2
	2	60	41	do. do. ..	7½d.	1 5 7
	3	81	60 {30 30	1st Bacon lowest range ... Darwin pork	7½d. 7½d	1 17 6
	4	96	73	1st Pork storage Darwin pork	7½d.	2 5 8
	5	66	49	do. do. ...	7½d.	1 10 7
	6	106	81	1st Bacon lowest range ...	7½d.	2 10 8
						£11 3 2
Average Dressing Percentage—74·5 per cent.						

A record of the cost of the foodstuffs used was kept, and thus it has been possible to compare the profit over the cost of feed for each group.

TABLE 7.

PROFIT OVER COST OF FEED.

Group No.	Value of Pigs.	Cost of Feed.	Margin—Value over Cost of Feed.
	£ s. d.	£ s. d.	£ s. d.
Group 1	25 10 7	9 2 0	16 8 7
Group 2	20 19 1	8 17 2	12 1 7
Group 3	13 13 2	5 6 1	8 7 1
Group 4	11 3 2	4 8 0	6 15 1

Further details showing the average weight increase for each pig, the quantity of grain and meatmeal consumed during the trial and also calculated per pound of live weight increase, together with the cost of feed per pound of live weight increase are given in Table 8.

TABLE 8.

——	Group 1.	Group 2.	Group 3.	Group 4.
Average weight at weaning (lbs.)	41·8	41·3	41·2	40·5
Average weight at end of trial (lbs.) ...	193·7	165·3	97·0	79·8
Average gain per pig (lbs.)	151·9	124·0	55·8	39·3
Amount crushed wheat consumed per pig (lbs.)	414·7	453·8	285·8	262·5
Amount meatmeal consumed per pig (lbs.) ...	61·2	22·2	4·7	...
Weight of feed per pound live weight increase (lbs.)	3·1	3·8	5·2	6·6
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total cost of feed per pig	1 10 4	1 9 6	0 17 8	0 14 8
Average cost per pound live weight increase (pence)	2·4	2·8	3·9	4·4

Photographs of the live pigs and of the carcases are shown in Figures 1 to 8.

The carcasses selected for Figures 6, 7, and 8 were those which approached most nearly to the average weight of each group. When the carcasses were cut down, measurements of the length of the sides, the width of the eye muscle, and the depth of the backfat were made and are shown in Table 9 together with an external measurement of all carcasses from the poll to the butt of the tail.

Discussion.

The evidence which has been obtained confirms the previous conclusions that meatmeal can be used successfully as a supplement to wheat. The rates of growth and development of groups 1 and 4, those receiving an ample supply of meatmeal and those receiving wheat only, are so widely different that if there was no other data available only one conclusion could be drawn, that the feeding of wheat alone is a most unprofitable method of feeding pigs.

Of the three groups receiving meatmeal, group 1 made the most rapid growth, produced the best carcasses and returned the greatest profit over the cost of feed: group 2, which received a reduced proportion of meatmeal throughout the trial, made relatively rapid growth, but not quite so rapid as group 1.

TABLE 9.

Group No.	Pen.	Dead Weight. (Average —Cold)	Tail Butt to Poll. (Average)	Length Aitch-bone to Symphysis 1st Rib and Sternum.	Aitchbone to Toe.	Depth Eye Muscle.	Back Fat.
		lbs.	inches.	mm.	mm.	mm.	mm.
1	1	161	42	719	550	43	32
	2	139	39				
	3	141	39				
	4	140	39				
	5	130	40				
	6	151	40				
	Average	144⅓	39⅚				
2	1	149	40	700	537	32	42
	2	127	38				
	3	86	35				
	4	116	38				
	5	128	38				
	6	139	39				
	Average	124½	38				
3	1	99	37	625	462	31	24
	2	55	32				
	3	84	35				
	4	79	34				
	5	77	33				
	6	43	27				
	Average	73	33				
4	1	53	32	575	488	26	19
	2	41	29				
	3	60	32				
	4	73	33				
	5	49	31				
	6	81	33				
	Average	59⅔	31⅔				

The quantity of food consumed per pound of live weight gain was the lowest in group 1, 3.1 lbs. of the ration mixture being required for each pound increase in weight. It will be noticed that the utilisation of food by groups 3 and 4 was particularly poor. The pigs in group 3 grew more rapidly for the first month than those in group 4, due to the inclusion of some meatmeal in their ration during that period. Being larger in size at the end of the month, their requirement for food was proportionately greater, while the rate of increase in weight from that time on to the end of the trial was no faster.

The total cost of feeding each pig was greatest in group 1 and the lowest in group 4, but owing to the greater rapidity of growth in the former group, the cost of food per pound of live weight increase, was lower than in the other groups. The cost of feed for each pound of gain increased as the proportion of meatmeal was reduced and was highest where wheat only was used.

It is therefore apparent that under conditions similar to those in the wheatbelt, the provision of meatmeal is not an added expense in feeding pigs, but is actually a means of reducing costs of production.

Fig 6.
An average carcass from each group. Groups 1 to 4 from right to left.

In an earlier trial at the Muresk Agricultural College (Hughes and Dixon) where no protein supplement was used in the grain allowance, only 3.93 lbs. of wheat were required to produce one pound of live weight gain, whereas in the present trial 6.6 lbs. of grain were needed. In the earlier trial, however, a quantity of green fodder, principally lucerne, was allowed to all pigs daily. This, no doubt, was largely responsible for the better utilisation of the wheat.

On slaughter there was no significant difference in the dressing percentage of the various groups.

The quality of the carcasses of group 2 were found to be generally inferior to those of group 1—see Table 6. Three of the six carcasses of the latter group were considered suitable as first grade for the local bacon trade and the other three were suitable for the export trade as first grade Wiltshire sides and one only (a light carcass) as fit for the local trade. It is explained that on a perusal of weight alone it might be considered that group 2, averaging 124½ lbs. per carcass, would be generally more suitable for the local trade than group 1, which averaged 144⅓ lbs. per carcass—as normally it is the heavier and usually fatter pigs which are exported, while the lighter, less fat pigs are retained for the local market. In this trial, however, the heavier pigs of group 1 were considered more suitable for the local trade than the lighter pigs of group 2. This classification was due to the relatively fatter condition of the carcasses of this latter group.

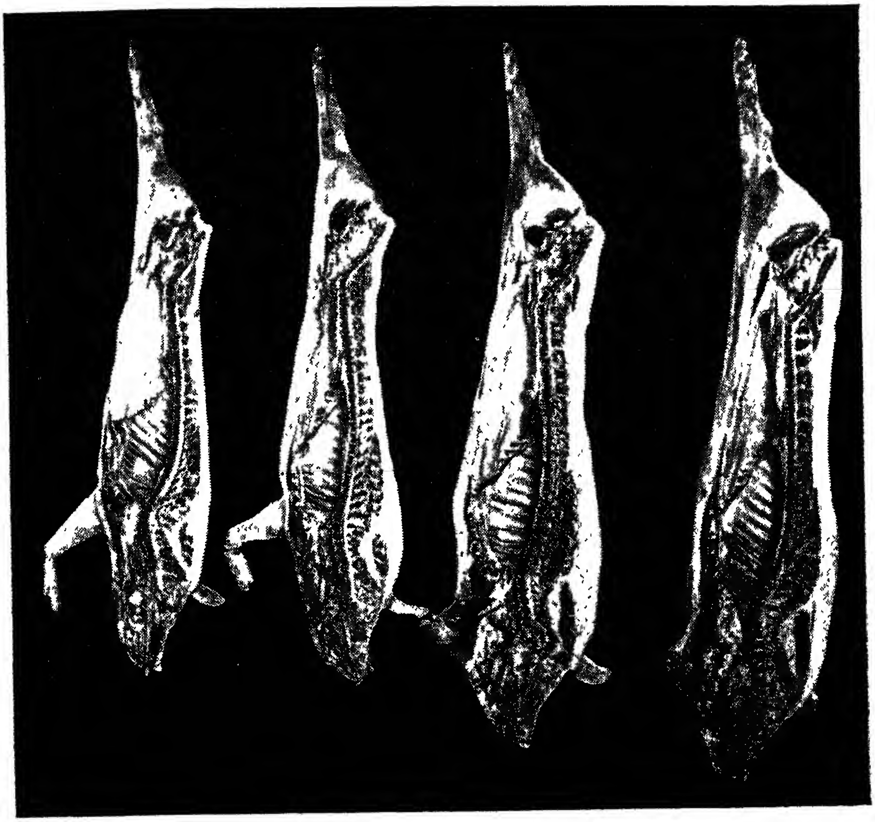


Fig. 7.
The carcasses in Fig. 5 were cut down. The sides are Groups 1 to 4 from right to left.

Although it was not possible to cut down each carcass for measurement, the details of the representative carcasses shown in Table 9 are interesting. The carcass nearest the average weight of each group was cut down into sides and again through the loin to enable photographs to be taken. Measurements of these sides indicated that the side from group 1 was considerably longer (19 m.m. or nearly 4/5ths of an inch) than that representing group 2. That this is probably a true index of the average for the whole of the groups is supported by the external measurements from poll to the base of the tail, which showed the pigs of group 1 to be 1-5/6ths inches longer than those of group 2. This comparison may be seen in Figures 6, 7, and 8, showing the carcasses, the sides and cuts through the loin of the four representative carcasses. It will be noticed that the depth of back fat in the sides is greatest in that from group 2, while the width of the eye muscle in the loin cuts is greatest in that representing group 1. From Table 9 it may be seen also that the respective depths of back fat in groups 1 and 2 are 32 m.m. and 42 m.m. respectively, the eye muscle measurements were 43 m.m. and 32 m.m. respectively. It appears reasonably conclusive, therefore, that the proportion of meatmeal fed to group 2 has not provided so satisfactory a result as that fed to group 1, and that if the proportion fed to group 1 is higher than necessary the amount of meatmeal fed cannot be reduced to the level of that fed to group 2 without affecting the rate of growth, the quality of the carcass and the profit.

In the feeding of group 3 an endeavour was made to ascertain whether it was necessary to feed meatmeal as a supplement throughout the period of growth of the bacon pig. From the results obtained it can be concluded that if meatmeal can be dispensed with, it cannot be left out of the ration as early as was the case in this trial.

It will be seen from figure 1 that while this group was receiving a ration of meatmeal its growth rate was intermediate between those of groups 1 and 2, but as soon as the ration was composed of grain alone an immediate slowing down of the growth rate occurred until it approximated that of group 4, which had not received any meatmeal at all. However the effect of meatmeal during the first month was evident in the increased growth of the pigs compared to those which received grain only. The average carcass weights were 72 and 59 lbs. respectively, while the average external length of the carcasses from poll to the butt of the tail was 33 and 31⅜ inches respectively. The eye muscle and the deposition of back-fat were both correspondingly greater. This result is no other than should be expected as it has been demonstrated so frequently that it is axiomatic that the young pig should be well fed on a narrower or higher protein ration than older pigs.

Fig. 8.

The sides in Fig. 6 were cut through at the last rib to show the backfat and the eye of meat. Groups 1 to 4 from left to right

The examination of the carcasses showed that some were very good, judged on the requirements of the local market. However as the period during which the trial was to have been concluded had to be lengthened by three weeks for reasons beyond control, the unsuitability of some carcasses for the local trade cannot be presumed to indicate the unsuitability of the breeding animals nor of the method for feeding for this market. As the weight ranges of the two heavier groups tended toward Wiltshire side weights it can be accepted that the amount of fat present was not excessive, otherwise they would not have been graded as first grade. When comparisons are made between these carcasses and the ideal, as described by Hammond, et al, it is seen that some considerable improvement is required. The amount of meat in the eye muscle and in the streak in the carcasses of group 1, as shown in Figure 8 is satisfactory, but this needs further improvement with a corresponding decrease in the thickness of the back-fat before the ideal carcass has been produced. The development of strains of more lengthy pigs which will not carry excessive fat at marketable weights will assist to this end. This aspect is considered highly important, as if the pig industry in Western Australia is to be expanded after the war, it can only be on the basis of the export market where competition will be met from bacon produced in Canada and in Denmark, which has been proved to be suitable to the requirements of the British public.

For this reason the further trials which are planned to investigate whether the quantity of meatmeal in the ration of group 1 is the optimum or whether it can be reduced profitably will include the appraisal of the carcasses.

Summary.

A trial in which various proportions of meatmeal were fed to pigs receiving a basal ration of wheat is reported.

The rate of growth was most rapid and the greatest profit was returned in the group receiving the greatest proportion of meatmeal. The slowest growth and the lowest profit was recorded for the group receiving no meatmeal.

The necessity of supplying sufficient meatmeal in the ration of the young pig is shown by the marked change in the rate of growth of group 3, when the ration was altered from one including meatmeal to one of wheat only.

The carcasses from the group receiving the greatest amount of meatmeal showed a superior meat development to those in the other groups, while the greatest deposition of fat occurred in the carcasses from the group which received a greatly reduced proportion of meatmeal, but which allowed fairly rapid growth.

ACKNOWLEDGMENT.

The thanks of the authors are due to Mr. A. H. Watson of Watson's Supply Stores for permitting the use of the staff and facilities of the bacon factory at Spearwood during the slaughter and treatment of the pigs, and to the members of the factory staff for their ready co-operation.

Bean Rust.

W. P. CASS SMITH.

During February a serious epidemic of bean rust developed in market gardens chiefly in the Balcatta and Osborne Park districts. Many crops of runner beans were completely ruined, and in consequence market prices rose sharply.

A survey of the affected areas showed that plantings on muck, or peaty swamp soils, where atmospheric humidity was high, were more seriously damaged than those on light sandy soils under sprinklers, and that french bean varieties, though affected with the disease, were highly resistant compared with runner types. Apparently this constitutes the first authentic record of bean rust in Western Australia, but from inquiries made, it seems reasonably certain that it has been present in the metropolitan area for several years at least to a limited extent. Many gardeners state that they have noticed the disease on occasions in the late autumn months, but that it caused little damage, as harvesting of all but late sown crops was then completed. Experience of the disease elsewhere gives added support to these observations, and it has been reported from New South Wales that bean rust is most serious there towards the end of the growing season, when it is more troublesome to home gardeners than to commercial growers.*

SYMPTOMS.

The disease may occur on any of the above-ground parts but it is most prevalent on the leaves. Practically all the injury is caused by leaf infections which, if numerous, may lead to complete defoliation. On the leaves the disease first appears in the form of small circular yellow spots which soon become raised, and later rupture, exposing the reddish-brown spore masses of the fungus. At first these spore-bearing pustules occur mainly on the undersides, but subsequently

*New South Wales Agric. Gaz., September, 1942, p. 428.

they develop on both surfaces of the leaves. (Plate 1.) On the pods, petioles, and stems the pustules are more irregular in shape and noticeably raised. (Plate 2.)

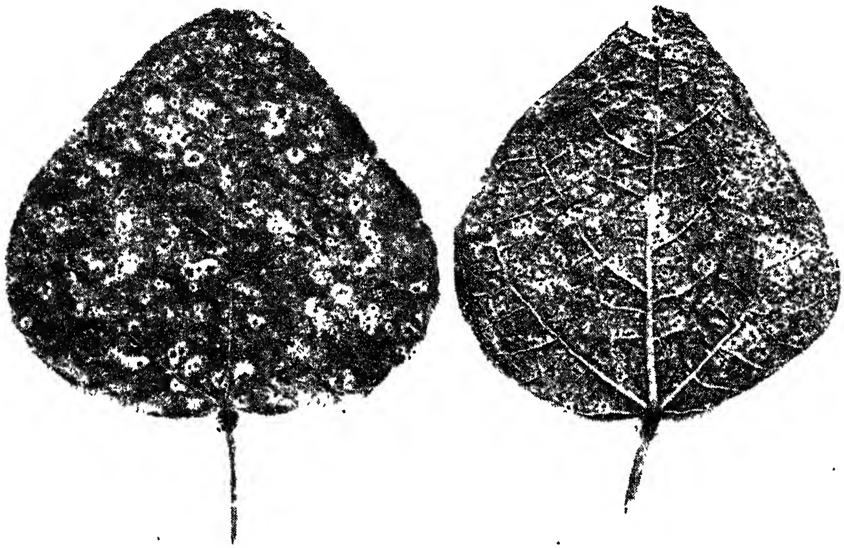


Plate 1.
Bean rust. Note at left on the upper leaf surface, circular yellow spots surrounding the rust pustules. At right note numerous spore-bearing pustules on the under surface.

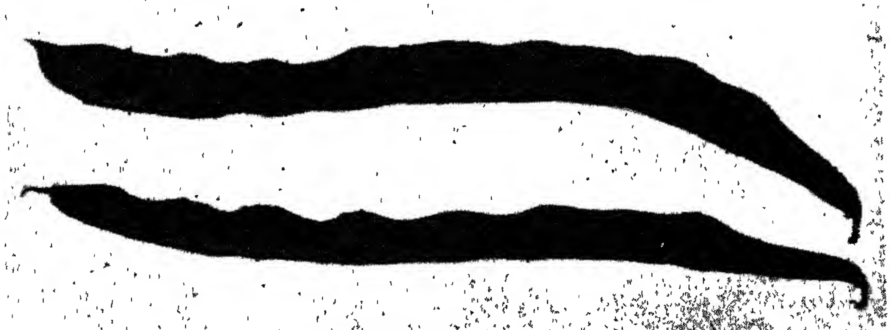


Plate 2.
Runner bean pods showing symptoms of rust. The pustules are raised and irregular in shape.

CAUSE.

Bean rust is caused by a fungus, *Uromyces appendiculatus* (Pers.) Fr. The reddish brown spores (uredospores) which are discharged in thousands from the pustules, are transmitted by wind, insects, rain, or other agencies, to neighbouring healthy plants where they may produce new infections. With suitable weather conditions the disease is rapidly spread by these spores, and in a few weeks the whole crop may be severely affected.

At a later stage the colour of the pustules changes to blackish-brown due to the production of spores of a different kind (teleutospores). These dark spores are thick walled resting spores which serve to carry the fungus over the winter months. The following spring the teleutospores germinate and with suitable conditions they cause new infections which lead to the appearance once more of the uredospore stage.

CLIMATIC CONDITIONS.

The development of diseases of this kind is greatly influenced by the weather, and this relationship is seldom fully appreciated. Some are capable of thriving under any conditions which favour the growth of the host plant but fortunately the development of many others including bean rust is restricted by a range of climatic requirements much narrower than that of the plant attacked. Thus diseases such as bean rust may linger almost unnoticed for several years, when their development is restricted by unsuitable weather, but in a season bringing climatic conditions which favour them, they may quickly multiply and reach epidemic proportions. During February the weather was unusually cool and muggy, which conditions are extremely favourable for this disease. In normal years, however, it would appear that similar conditions are not likely to be encountered until later in the season, by which time all except late crops will have been harvested.

CONTROL.

Resistant Varieties:

Bean rust is best controlled by growing resistant varieties. In Western Australia the "white-seeded runner bean," sold commercially under various names, including Prolific, Abundance, and Golden Harvest, has practically superseded all other runner bean types, owing to its high resistance to bacterial blight.

Accordingly observations of varietal reactions to the disease have been limited, but in general, french bean types, including the Vincent variety which is fairly resistant to bacterial blight (*), showed greater resistance than runner beans.

Owing to the occurrence of races of the bean rust parasite, each of which may attack different varieties, it does not follow that a variety will maintain its resistance in all localities. If the disease proves to be troublesome in future years it will be necessary to test varieties locally.

Fungicides.

The application of fungicides to control the disease is worthy of trial under our conditions. Lime sulphur 1-80 to 1-100, or a dust containing equal parts of sulphur and air-slaked lime, are recommended for this purpose. Both these fungicides will help to control red spider, which is troublesome in bean crops during the summer months. Either spray or dust should be applied immediately the disease is noticed, and thereafter at weekly intervals unless unfavourable weather checks the disease.

Hygiene.

After harvesting is completed all crop remains should be removed and destroyed to reduce the infection of later sown crops, and to prevent as far as possible the carry-over of the disease through the winter months.

In pre-war days this practice was general, but since the war it has been largely neglected owing to various difficulties.

The Influence of Topdressing with Copper Sulphate on the Copper Content and the Yield of Mixed Pasture at Gingin.

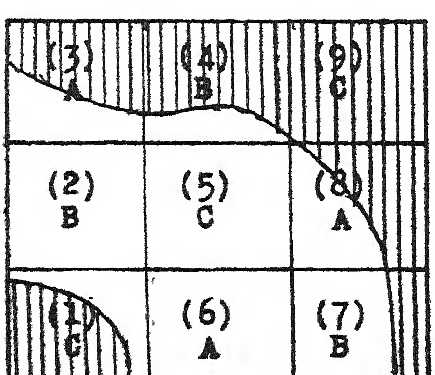
E. J. UNDERWOOD, T. J. ROBINSON, and D. H. CURNOW.

It has been shown that the disease "Gingin Rickets" or "enzootic ataxia" of lambs is due to a copper deficiency (Bennetts and Chapman, 1937; Bennetts and Beck, 1942). This disease can be prevented by the administration of suitable copper containing licks to the mother and there is now ample evidence that the benefits of such licks are not confined to the prevention of ataxia. Optimal growth in lambs and a marked beneficial effect on the health and the wool quality of the adult are obtained. There is also evidence that the topdressing of pastures with copper compounds in the affected areas will raise the copper content of the pasture to "normal" levels and thus bring about the same results. In fact there is a strong suggestion that the treatment of pastures is the better method of the two. There is a marked absence of information, however, as to the optimal rate or rates of copper topdressing for this purpose, or of the period of effectiveness and the effect on yield if any. It was decided therefore to carry out an experiment to provide data on these points as a guide to future more detailed studies. The results are described below, together with some studies of species differences in copper content.

Some experimental information on this problem has become increasingly important as more and more evidence accumulates that areas copper deficient both for stock and for the growth of crops, are much more widespread in W.A. than was supposed when the first investigations were being made. The results of experiments in one area will not necessarily apply to others since the nature of the response to treatment with copper depends very significantly on such factors as the soil type and the plant species grown. The Gingin district seemed a good place for an experiment since considerable information on copper deficiency in stock was already available and in addition a soil survey of the area had been carried out. (Hosking and Greaves, 1936).

LOCATION AND LAYOUT OF EXPERIMENT.

An area of pasture on the Wedge Estate at Gingin was chosen. The area is made up partly of "Whakea sand" which is a predominant soil type in this district and partly of "Minjil sand." The distribution of these two types of soil in the experimental area is shown on the plan below.* An area 4½ x 4½ chains was



A—Controls—No copper.

B—7.5 lbs. copper sulphate per acre.

C—15 lbs. copper sulphate per acre.

"Whakea" sand

"Minjil" sand

fenced and divided up into nine plots 1½ x 1½ chains in size in the form of a 3 x 3 Latin square, as shown on previous page.

In April, 1939, shortly after germination of the pasture species treatment was given to the plots as follows:—A plots, superphosphate only at the rate of 30 lbs. per acre; B plots, superphosphate at the same rate plus copper sulphate at the rate of 7.5 lbs. per acre; C plots, superphosphate at the same rate plus 15 lbs. copper sulphate per acre. The copper sulphate was mixed with the superphosphate and spread by hand on each plot divided into four to ensure even distribution. No further treatment with copper was given, but in the early autumn of the following two years, 1940 and 1941, all the plots were topdressed with 90 lbs. superphosphate per acre.

Sampling was carried out four times in each year on approximately the same dates by clipping five random yard squares from each plot. The samples from these were oven-dried and weighed separately for the estimation of dry weight yields and kept for chemical analysis. The times of cutting in each year were as follows:—

First cut; mid-June—Short young green growth.

Second cut; mid-August—Well-grown green growth, before flowering.

Third cut; mid-September—Fully-grown, flowering, partially mature.

Fourth cut; end-October—Mature, dry.

After each sampling a very large number of sheep were grazed on the plots in order to eat the pasture right down within a few days. It is important to note that the sum of the yields represents therefore the total yield of herbage available in each year from this type of grazing and the copper content of the successive samplings allow estimates of the seasonal copper intakes of grazing animals to be made.

At the beginning of the experiment all the plots were sown with wimmera rye grass and subterranean clover, each at the rate of 4 lbs. seed per acre. The seed was distributed by hand on the surface after light scarifying. Neither of these species contributed greatly to the bulk of herbage produced in the first year, although the proportion, particularly of Wimmera rye grass, was very much greater in 1940 and 1941. In 1939 the main pasture species was capeweed (*Cryptostemma calendulaceum*) with such poor annual species as silver grass (*Festuca* spp.) various brome grasses (*Bromus spp.*), barley grass (*Hordeum murinum*), cluster clover (*T. glomeratum*), woolly clover (*T. tomentosum*) and some subterranean clover (*T. subterraneum*). The capeweed, although forming a considerable proportion of the pasture was not nearly so dominant in the two following years.

RESULTS.

Pasture Yields.

The yields were obtained by averaging the five yard squares on each plot and taking the mean of the three plots of each treatment. The results, calculated as cwts. of dry material per acre, are given for the three years of the experiment in Table 1.

The most noticeable thing about Table 1 is the very great increase in total yield in 1940 and 1941 compared with 1939. This was in spite of the fact that 1939 was a very good season with a total rainfall incidence between April-October of 31.8 inches, whereas in 1940 the rainfall during the same period was only 15.5 inches. In 1941 it was 27.6 inches. Undoubtedly the dominant reason for this was the development of more productive species, particularly Wimmera rye grass, and to a lesser extent subterranean clover in the second and third year. These did

not grow well in the year in which they were sown. The heavier dressings of superphosphate in these two years, compared with the small dressing in 1939, perhaps contributed to this development, although the regular system of heavy rotational grazing may also have been important. Controlled experimental evidence on the influence of these factors is needed.

TABLE 1.

PASTURE YIELDS.

Cwts. per acre of dry material.

Treatment.	Year.	Mid-June.	Mid-Aug.	Mid Sept.	Late Oct.	Total.
No copper	1939	Samples taken but not weighed	4·2	4·0	6·0	14·2
Copper Sulphate—7·5 lbs. per acre	,,		4·2	4·3	5·2	13·7
Copper Sulphate—15 lbs. per acre	,,		4·1	3·9	6·4	14·4
No copper	1940	0·6	10·0	15·5	20·0	46·1
Copper Sulphate—7·5 lbs. per acre	,,	0·7	12·0	12·0	18·0	42·7
Copper Sulphate—15 lbs. per acre	,,	0·6	10·0	10·0	13·6	34·7
No copper	1941	5 9	14·5	17·5	18·6	56·5
Copper Sulphate—7 5 lbs. per acre	,,	6·5	14·8	18·4	17·2	56·9
Copper Sulphate—15 lbs. per acre	,,	5·6	13·4	12·6	14·0	45·6

In 1939 no difference in average yield between the copper treated and the untreated plots was evident, either in the total for the year or at any stage of the season. The same is true for the early part of the following two seasons. Thereafter, there was an apparent decrease in total yield in the copper treated plots in both 1940 and 1941, particularly in the plots receiving the heavier dressing (15 lbs. copper sulphate per acre). This effect was more noticeable in the final sampling in 1940 than in 1941. Statistical treatment of the individual cuts, however, revealed that this difference is not significant. It is due to the great variability of the individual cuts and also to the very poor growth on one of the "C" plots (receiving 15 lbs. of copper sulphate per acre), namely, plot 1. It will be noted that more than half of this plot consists of "Minjil" sand. The poor yield cannot be attributed to this fact alone, however, as plot 9, also a "C" plot, consists entirely of "Minjil" sand, and yielded as well as the surrounding plots, including number 5. In fact the individual plot yields show no correlation with soil type differences.

It is evident that with pasture of such variability as that on which this experiment was carried out many more replications and a different design is necessary if small differences in yield, due either to a beneficial or a deleterious effect of the copper dressings, are to be revealed. Nevertheless, the absence of any reduction in yield in the copper treated plots in the first year, when the copper was put on, makes it appear very unlikely that a dressing of 15 lbs. of copper sulphate is toxic on such soils with the particular plant species present. It has, however, been shown by Teakle (1941, 1942) that applications of copper sulphate at rates in excess of 10-15 lbs. per acre depress yields on some Western Australian soils.

COPPER CONTENT OF PASTURES.

The copper content of the pastures was determined by a method based on that of Sylvester and Lampitt (1935). In 1939 analyses were carried out on each separate yard square, that is, on five samples from each plot or 45 samples at

each cutting. In the two following years the aliquots of the five cuttings from each plot were taken after drying and grinding, and analysis of the mixture of these aliquots carried out. The mean figures for the copper content of the mixed pasture from each treatment set out in Table 2 represent the average of 15 separate analyses (five from each of three plots) in each case in 1939. In 1940 and 1941 these figures represent the average of three separate analyses only, although the three samples analysed were, as explained above, a mixture of five separate quadrats. The results are expressed as parts per million on the dry basis.

In the first year, when the copper was applied, the top-dressing with bluestone, at both the lower and higher rates, has been very effective in raising the copper content of the herbage to adequate values. This effect is highly significant for the season as a whole (at the $P = .01$ level) and is equally so during the following year, 1940. In 1941, the third season following treatment, there is still a significant effect from the higher level of treatment and the copper content of this herbage can be regarded as easily adequate for the requirements of grazing stock. An increase in copper content from the lower level of treatment has also been maintained into the third season, but the effect is less marked. In fact it is barely significant by the same statistical tests and the mean value for the season is hardly high enough to provide a really satisfactory copper intake for grazing animals. Most Western Australian pastures from "sound" areas known to be healthy for stock contain 7-14 ppm. of copper, but present evidence indicates that a level of 6 ppm. can be regarded as adequate.

TABLE 2.

COPPER CONTENT OF PASTURES.
ppm. Cu on dry basis.

Treatment.	Year.	Mid-June.	Mid-Aug.	Mid-Sept.	Late Oct.	Mean.
No copper	1939	not analysed	5·4	5·0	5·0	5·1
Copper sulphate—7·5 lbs. per acre .	,,		8·4	8·5	6·5	7·8
Copper sulphate—15 lbs. per acre	,,		9·8	11·0	8·8	9·9
No copper	1940	5·3	3·8	4·3	3·7	4·3
Copper sulphate—7·5 lbs. per acre	,,	10·3	5·9	7·2	4·5	7·0
Copper sulphate—15 lbs. per acre	,,	11·4	6·0	8·9	6·4	8·2
No copper	1941	2·6	4·4	3·3	not analysed	3·4
Copper sulphate—7·5 lbs. per acre	,,	4·3	5·2	5·9		5·1
Copper sulphate—15 lbs. per acre	,,	5·3	6·7	9·1		7·0

The only comparable figures from mixed pasture are those given by Bennetts and Beck (1942). These workers found that treatment of similar pasture at Gingin with 20 lbs. copper sulphate per acre raised the copper content from the 3-4 ppm. of adjacent areas to 10-15 ppm. in the year of treatment. This remained at 10-11 ppm. in the growing period of the following year and one sample taken in the third year showed a value of 7.6 ppm. on the dry basis. This compares particularly well with the result from the treatment with 15 lbs. per acre in the present experiment.

A very interesting aspect of Table 2 is the variation in copper content of the untreated plots in the three years of experiment. It will be seen that there is a small but consistent fall from 1939 to 1941. In 1939 the values are higher than would be expected from the work of Bennetts and Beck (1942) on other

Gingin pastures taken in the same and in previous years. In the two following years the values, although lower, are still not quite as low as those of Bennetts and Beck. The higher values in 1939 may have been influenced by the greater proportion of capeweed in the pastures in this year since, as will be shown later, this species carries under some conditions a higher copper content than other species growing with it, such as subteranneau clover and Wimmera rye grass. The possibility that differences in the seasonal conditions have significantly affected the copper content must also be taken into account. As in the case of the yield figures there is no correlation between the copper content of the individual plots and the distribution of the two soil types on the experimental area. In other words it can be stated that within the limits of the present experiment "Whakea" sand and "Minjil" sand show an equal evidence of copper deficiency.

A decided improvement in the health of grazing stock in the late spring in copper deficient areas is well known. This would imply a higher copper content of the pasture at this time, but the data of Table 2 do not support this. In fact the values for mixed pastures tend to be lower at this time of the year when the pastures are mature. A similar finding with mixed pasture was made by Beck (1941). At other times of the year there do not seem to be any consistent differences in copper content which can be correlated with stage of growth. It should be stressed that in the present experiment the grazing conditions were strictly controlled. After each sampling the pasture was grazed almost bare within a few days and then left ungrazed until the next sampling period.

COPPER CONTENT OF DIFFERENT PLANT SPECIES.

Ample evidence is available from other work in W.A. and elsewhere that different plant species vary considerably in their copper content when growing under the same conditions and absorb copper differently from varying soil types. Accordingly, it was necessary to obtain some information as to the copper content of the main species in the pasture under investigation. All of the above analyses, as explained earlier, are of mixed pasture samples, since the primary object was to measure the ability of the pasture as a whole, under the different treatments, to supply copper to grazing stock. To have obtained this information, together with a measure of the contribution of the different species making up the pasture, would have involved a tremendous amount of extra work in separation, weighing and analysis. A series of samples of subterranean clover, Wimmera rye grass, and capeweed, growing together, were therefore taken, both from the Gingin plots and from pasture very recently laid down on a podsolised sand at Perth. The results are presented in Table 3.

It is seen that subterranean clover and wimmera rye grass are very similar in copper content, both at Gingin and Perth. Capeweed, on the other hand, is consistently higher at Perth and in the later cuts at Gingin. An August, 1941, at Gingin the three species show little difference between each other at either of the levels of treatment with copper. Apparently capeweed absorbs copper more readily from some soils than do certain other pasture species. This has already been suggested from some rather limited evidence in other parts of W.A. (Teakle *et al*, 1941 and Beck, 1941) and in New South Wales (Aust. Wool Board Report, 1940). It should be made clear, however, that under some conditions capeweed analyses can be a very valuable indicator of copper deficiency. Very low copper values for capeweed have been found recently by Bennetts and Underwood (1942, unpublished data) from certain areas where copper deficiency symptoms in sheep have been demonstrated.

TABLE 3.

COPPER CONTENT OF DIFFERENT PLANT SPECIES.

ppm. Cu on dry basis.

Source.	Date.	Sub-terranean Clover.	Wimmera Rye Grass.	Capeweed.
Gingin "Whakea sand"—No added copper	15–8–41	3·4	4·0	3·3
Gingin "Whakea sand"—Copper sulphate, 7·5 lbs. per acre	"	6·7	8·0	5·3
Gingin "Whakea sand"—Copper sulphate, 15 lbs. per acre	"	9·0	8·7	9·0
Gingin "Whakea sand"—No added copper	15–9–41	3·1	3·0	5·0
Gingin "Whakea sand"—Copper Sulphate, 7·5 lbs. per acre	"	7·1	5·2	10·2
Gingin "Whakea sand"—Copper sulphate, 15 lbs. per acre	"	8·4	5·7	13·6
Perth sand—no copper added	24–9–40	3·5	2·8	6·4
Perth sand—no copper added	29–7–41	5·5	6·3	7·3
Perth sand—no copper added	1–9–41	4·2	3·9	5·8
Perth sand—no copper added	5–8–42	4·9	4·1	9·7
Mean	...	5·6	5·2	7·6

DISCUSSION.

Although no improvement in yield of pasture was obtained from the copper treatment, a similar lack of response should not be assumed in other areas where copper deficiency in stock is known to exist or even with other crops in the same area. Thus Teakle *et al* (1941) have obtained an increase of oaten grain on "Wakhea sand" at Gingin and observed some of the symptoms of copper deficiency in the growing oat crops. It is the experience of farmers in the district that crops of oaten hay are improved by the use of copper containing fertilisers. There is also some evidence of improvement in pastures in certain parts of the Gingin district, although experimental data on this point is so far lacking. It is expected that experiments now being carried out by the Plant Nutrition Branch of the Department of Agriculture will go some way towards providing the necessary evidence.

The pronounced effect of the copper treatments on the copper content of the herbage without any corresponding effect on yield, is a matter of considerable practical significance. It is important to realise that a copper deficient soil can affect pastures by lowering yield; by altering the botanical composition; by producing herbage of lower copper content, or by one or all of these effects. Under certain conditions, a lower copper content may be the only result of the deficiency. This deficiency may not affect pasture growth and appearance, but may reduce the copper content of the herbage to such an extent that it is below the requirements of grazing stock.

The Gingin district, although definitely copper deficient, is not so severely deficient as parts of the Busselton-Margaret River area for instance, where even lower pasture copper levels consistently occur (Bennets, *et al* 1941, Beck 1941), and where yield and botanical composition are also affected. At Gingin, judging by the results of the present experiments, the copper status is such that the common pasture species maintain their yield but with a lower copper content than

similar species in more favoured areas. With a more severe deficiency or with the introduction of pasture species with a higher copper requirement, yield as well as copper content is likely to be affected.

It is apparent that there is a considerable residual effect from the copper sulphate treatments. In the case of the 15 lbs. per acre level this has been sufficient to maintain satisfactory copper values in the herbage into the third season following treatment, while even with half this level there has been a small but significant raising of the copper content in the third year. In practice therefore it is not only unnecessary to topdress with copper every year, but it seems highly probable that rates of application below those used in this experiment would, over a period of years, be perfectly satisfactory. Definite recommendations on this important matter must await the results of further experiments, some of which, as pointed out previously, are already being undertaken by the Department of Agriculture.

SUMMARY.

An experiment was carried out to determine the effect on the yield and copper content of mixed pasture, in an area at Gingin copper deficient for stock, of topdressing with copper sulphate at levels of 7.5 lbs. and 15 lbs. per acre.

No significant effect on the yield of pasture was obtained from either of the treatments.

A marked effect in raising the copper content of the pasture was given by both levels of topdressing. For three seasons following treatment the heavier dressing maintained the copper content of the pasture at a level known to be adequate for the health of grazing stock. The lighter dressing maintained satisfactory levels for two seasons, and some improvement in copper content was still noticeable in the third year.

It is concluded that treatment with 15 lbs. copper sulphate per acre every third year or half that quantity every second year is more than ample to maintain the copper content of pasture on similar soils in such areas at an adequate level for grazing stock. Over a period of years it is probable that much smaller quantities would be quite satisfactory. Evidence on this point is now being obtained.

No significant differences in copper content were found between subterranean clover and Wimmera rye grass growing under the same conditions and at approximately the same growth stages. In one area capeweed was found to be consistently higher in copper content than either of these two species.

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Butter Boxes.

The Effect of Western Australian Timbers on the Flavour of the Surface of the Butter.

M. CULLITY, Superintendent of Dairying.

In Western Australia butter intended for export or for storage under the Dairy Products Marketing Scheme is packed in hoop-pine boxes which have been sprayed with a casein-formalin mixture evolved by Dr. J. Wiley of the Council for Scientific and Industrial Research.

During 1942, owing to various difficulties, a shortage of hoop-pine boxes occurred and although supplies were eventually received, in which the bulk of the State's surplus butter was packed, portion of the surplus was stored in boxes made from a variety of timbers. Much of this butter acquired a strong surface wood taint.

It was feared that a further, more serious shortage might occur and consideration was given to the possibility of procuring supplies of boxes made from the most suitable local timbers.

As it was possible that butter might remain stored in local timbers for long periods, or in certain circumstances be exported, it was decided at a Conference of representatives of the Institute of Dairy Factory Managers, the Forestry Department and the Department of Agriculture, that trial boxes of various timbers be made and sprayed with the casein-formalin mixture.

The degree of taint on the surface of the butter packed in these boxes was to be compared with that on butter packed in unsprayed boxes of the same timbers. Seasoned mature karri, young karri, jarrah and blackbutt, having less than 15 per cent. moisture, were selected for the trial.

Twelve boxes of each were made by Mr. F. Simper at the Safety Box Company Factory, Fremantle.

The preparation used for spraying was:— Water, 5 parts; casein, 1 part; caustic soda, 1/16th part.

The formalin solution was diluted 1 : 7 with water. Spraying was carried out, using pumps removed from knapsack spray outfits.

Some difficulty was experienced in obtaining an even coating of the interior surface of the boxes which were already made up, but examination later showed that this had not proved a serious defect.

On the same day three black-butt boxes were sprayed on the flat—that is, before being made into boxes—and it was found that spraying could be carried out much more easily and rapidly.

The boxes were forwarded to the South-West Co-operative Dairy Farmers' Bunbury factory, where they were packed with butter on the 25th September and returned to Perth, where they were held in store at the Sunny-West Dairies.

Sample boxes of each timber were examined on the 9th, 16th, 23rd and 30th October, 1942, and the 21st January, 1943, the last series having been in store for almost four months.

It was apparent beyond any doubt that the black-butt timber which it had been suggested might be suitable, was extremely disappointing as the butter paper and the butter were badly stained and tainted.

The boxes made from karri were far superior to the black-butt, but some small degree of taint was discernible on the surface of the butter. This applied to both the mature and the young karri. While the taint was discernible, it was considered not so pronounced as that imparted to butter from hemlock and spruce.

Jarrah was still more successful: butter in the unsprayed boxes had less taint than those packed in the other untreated timbers and was superior to that in the sprayed black-butt boxes. In only one box did the taint from jarrah appear to be more than that from karri.

Examination of the butter from the sprayed jarrah boxes was particularly pleasing inasmuch as no discoloration of the lining papers, nor wood taint on the surface of the butter, could be detected. These boxes were definitely superior to the others used in the trial.

It was the unanimous opinion of those present at the examination of the butter, that it could not have opened up any better if it had been packed in sprayed hoop-pine boxes.

It should be explained, however, that for the purpose of the trial the box manufacturer was asked to procure jarrah cut from a young tree. In order to comply with this request at short notice, the boxes were cut from a telegraph pole which had been in use for 15 years. Accordingly the results obtained could not be considered completely reliable as an index to the effect of newly-seasoned young timber. One series of boxes was held in the ante room for a week to encourage the sweating of the butter, in order to ascertain whether greater staining would occur. No additional damage was noted.

After the examination of the butter on the 30th October, it was decided that a further trial should be commenced using new timber from mature jarrah trees. Again reliance had to be placed on the manager of the box factory to procure suitable logs.

Three sets of eight boxes each were manufactured from:—

(1) green timber;

(2) semi-dry timber—25% moisture;

(3) dry timber—under 16% moisture.

The timber was darker in colour (red) than in the first series of boxes and to that extent confirmed the greater maturity of the timber.

The boxes were made on the 6th November and four of each group were sprayed immediately.

These boxes were packed with butter at the South-West Co-operative Dairy Farmers' factory at Bunbury on the 13th November, and after storage were examined on the following dates: 18th December and 21st January.

The comments made were of the same order on each inspection and are as under:—

(1)	Green jarrah—unsprayed ..	strong wood taint.
	Green jarrah—sprayed	very strong wood taint—boxes warped and timber shrunk.
(2)	Semi-dry jarrah—unsprayed ..	easily detectable wood taint.
	Semi-dry jarrah—sprayed ..	very faint taint.
(3)	Dry jarrah—unsprayed	faint taint.
	Dry jarrah—sprayed	no taint.

In all unsprayed boxes slight staining of the paper was noticeable, while in the sprayed boxes the papers were slightly stained at the junction of the boards.

The result of these trials may be summarised as showing that the jarrah which had been seasoned and sprayed with the casein-formalin mixture did not taint the butter.

In the possible event of emergency, therefore, in which normal supplies of the approved type export boxes were unavailable, seasoned jarrah sprayed could be used with some confidence that the butter would not deteriorate unduly because of timber taint.

As a result it was suggested to the manufacturers of butter that they should protect themselves and the industry, by making suitable arrangements so that seasoned jarrah boxes would be available if needed. It should need no emphasis to indicate that unless preparations are made well before any emergency could arise, it might prove difficult at short notice to get jarrah dry enough to avoid tainting of the butter.

To pursue this matter further, it is hoped to arrange a small shipment for export so that a report may be procured from London.

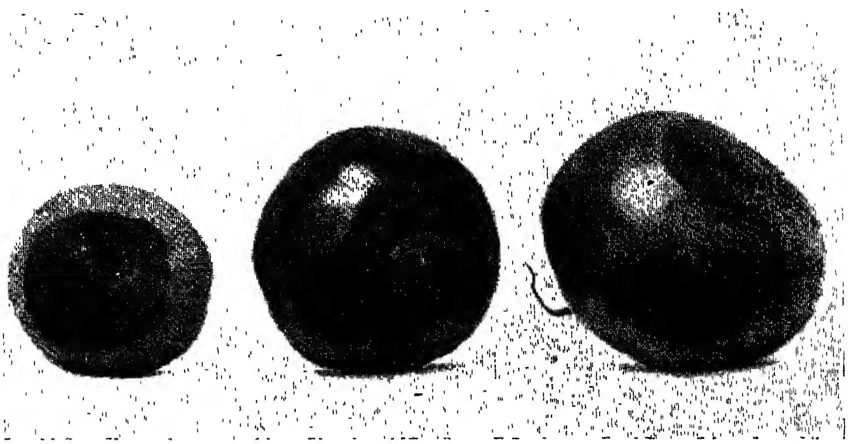
It is pointed out that while some jarrah boxes are used successfully in the local trade, no attempt has been made in this trial to compare timbers on any basis other than their capacity to transmit taint to butter. For example, jarrah has not been compared with other timbers on the basis of its weight, colour, ease of handling, ease of wiring, its inclination to shrink and expand, or its re-use value.

Blossom-End Rot of Tomatoes.

W. P. CASS SMITH, Plant Pathologist.

During the summer months many tomato specimens were received showing symptoms of blossom-end rot; in most cases the growers concerned attributed the trouble to parasitic causes and were anxious to prevent it spreading. However, blossom-end rot is a non-parasitic trouble, in the development of which soil and climate play an important part, and it cannot be controlled by sprays.

While the exact relationship of environmental and genetic factors to the occurrence of the disease is not completely understood, it is generally accepted that the ultimate cause of blossom-end rot is a deficiency of water at about the time the fruit is ripening. When water becomes deficient the fruit cannot compete with the rest of the plant for it, and thus the cells of the fruit furthest from the water supply, i.e., at the blossom-end, collapse and die.



Blossom-end rot of tomatoes.

[After Carne.]

It is, therefore, understandable why blossom-end rot is prevalent when the soil becomes too dry, but because the disease is also prevalent at times when the soil is wet, growers are sometimes not readily persuaded that water deficiency is the cause.

Plants require large quantities of moisture from the soil for their growth especially during the summer months; but the amounts retained and combined with food materials to make new plant tissues are very small. The surplus water is drawn from the foliage into the air, the amount lost being regulated by such factors as air temperature, humidity, wind and type of plant.

On hot summer days, especially when strong drying winds prevail, the amount of water lost from the foliage may increase enormously. When this occurs the roots even in *wet soil* may be incapable of supplying water fast enough to balance the rate of water loss and the plant becomes "stressed" for moisture. If "stressing" is too prolonged portions of the plant commence to wither and withering continues until the water balance is restored.

As already explained, when ripening fruit is present on the tomato vine, withering commences in the cells at the blossom-end; and it becomes obvious by the appearance of a putty coloured to dark brown, or blackish rot (see Plate). The rotted area may be small or it may extend over half the total surface of the fruit, and if it is invaded by secondary organisms the whole fruit ultimately decays. Under the conditions prevailing in this State, this type of water deficiency, induced by hot drying winds appears to be the commonest cause of blossom-end rot; the disease is also prevalent when the soil is allowed to become too dry following a plentiful water supply as, e.g., when tomatoes are grown under sprinklers, or irrigated.

As the disease is largely caused by climatic factors, control is difficult. Nevertheless, it may be reduced considerably by attending to the following points:—

Increase the water-holding capacity of the soil and the size of the root system by the incorporation of humus forming materials and by applications of superphosphate and potash manures. Reduce water loss from the foliage:—by applying the smallest necessary amounts of nitrogenous manures such as poultry manure, blood and bone, sulphate of ammonia, etc., which encourage succulent leaf formation—by the use of sprinklers during heat waves to increase atmospheric humidity

and keep the soil moist—and by the employment, where practicable, of wind breaks. In general it has been found that nitrogenous manures tend to increase blossom-end rot, whereas potash manures have a reverse effect, and that plants watered with amounts sufficient for healthy growth are more resistant than those over-watered or watered irregularly.

Wheat and Oat Variety Trials, 1942.

I. THOMAS, Superintendent of Wheat Farming, and
A. J. MILLINGTON, Field Technician.

WHEAT.

Wheat variety trials were conducted during 1942 at the five widely distributed Research Stations and also, under departmental supervision, on two private farms.

Details of the monthly rainfall at the research stations are as below, together with the average over the period since each station's inception.

Year.	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
					AVONDALE RESEARCH STATION.									
1942	7	8	153	80	161	276	266	277	105	46	1,131	.	186	1,565
Av., 16 years ...	27	42	111	84	229	299	303	238	105	93	1,266	46	38	1,615
					CHAPMAN RESEARCH STATION.									
1942	24	.	23	209	403	428	242	227	136	91	1,527	..	..	1,783
Av., 37 years ...	27	38	69	73	238	422	384	269	151	91	1,555	36	26	1,825
					MERREDIN RESEARCH STATION.									
1942 .	37	8	132	106	205	181	169	169	76	40	840	24	317	1,464
Av., 31 years .	46	51	96	86	133	187	179	147	80	81	807	43	62	1,193
					SALMON GUMS RESEARCH STATION.									
1942 . ..	36	104	595	177	121	134	139	220	92	255	961	5	188	2,066
Av., 17 years ...	104	63	148	91	129	141	142	158	89	126	787	95	74	1,362
					WONGAN HILLS RESEARCH STATION.									
1942 . ..	28	..	491	91	428	191	173	243	153	45	1,233	5	85	1,933
Av., 17 years .	36	47	104	92	192	246	255	196	94	77	1,060	44	48	1,429

The actual monthly totals do not give a true picture of the seasonal conditions as from May to August there were periods when rain was practically a daily occurrence, the effect being most severe at Chapman and least at Avondale and Salmon Gums. Details regarding growing conditions at the Research Stations can be briefly summarised as follows:—

Avondale.—Despite rather difficult periods during seeding operations, seasonal conditions were generally satisfactory for both crops and pasture. Crop yields reflect the conditions as also did the stock, the growth rate of the lambs being higher than the previous year.

Chapman.—As far as the grain crops were concerned, the season was a failure, excessive and continuous rains negatived any weed control resulting in choked out crops and very low yields. Pasture growth was, however, excellent, particularly with the sown pastures. The pasture conditions were reflected by the excellent condition of all stock throughout the season.

Merredin.—Early seasonal conditions were quite good, though the rather persistent rains increased weed growth during planting. Portion of the crop was, as a result, planted later than desirable. The lack of finishing rains reduced the yields of the early sown crops and seriously affected the late sown crops. The Bungulla planted in May yielded approximately 23 bushels, whereas that planted in late June, yielded 10 bushels per acre. Pasture growth was satisfactory with an excellent wool clip.

Salmon Gums.—One of the most satisfactory seasons for many years was experienced; crop and pasture growth was excellent, record yields were not obtained, but results were affected particularly for the oats, by storm damage. Pasture growth, especially the wimmera rye grass was excellent and an excellent wool clip was obtained.

Wongan Hills.—During the early part of the growing period conditions were very wet and cold, making seeding operations difficult and retarding growth. Conditions improved somewhat during the latter part, but lack of finishing rains affected the yields which, however, must be considered satisfactory under the circumstances.

Under the diversity of conditions encountered, Bencubbin yielded consistently and remains the most prolific variety under test.

The objective of the departmental breeding programme, therefore, is to produce new varieties which, whilst they retain the yielding ability of Bencubbin, are superior in respect to rust resistance and straw strength. Some success in the direction of this objective has been achieved in the varieties Koorda and Kondut which were released for general cultivation during 1942-43. Both Kondut and Koorda closely approach Bencubbin in yielding ability and have much stronger straw.

The variety Kondut is slightly later maturing than Bencubbin and in view of its excellent straw strength, it is an ideal variety for early plantings, principally in the higher and more favoured rainfall districts and can be considered particularly suited for light land in such districts. Under suitable conditions, Kondut yields flour of almost premium strength.

For later plantings, Koorda has been bred as a suitable alternative to Gluyas Early, Totadgin and Merredin. Notable for its stout, strong, straw, Koorda can be considered the early maturing counterpart to Kondut.

Situated in an area of occasional rust epidemics, the Chapman Research Station is of value as a site for testing varieties resistant to this disease.

Over a five-year period, the rust resistant variety Fedweb has consistently outyielded Nabawa by a small margin. The rather late maturity of Fedweb has resulted in its cultivation being restricted to the wetter and most favourable wheat growing localities.

The very rust-resistant Eureka varieties were tested in 1941 and again in 1942. Eureka 1 is early maturing, but sheds rather too freely to have wide acceptance as a variety. The mid-season maturing, Eureka II. holds its grain well and has yielded satisfactorily in extensive yield trials.

The Waite Institute variety Warigo was under test for the first time in 1942. Although inclined to be weak strawed, Warigo yielded fairly satisfactorily, having due regard to the most unfavourable growing conditions. In view of its resistance to rust, it will be included in further trials.

Details of the yields obtained are set out in the accompanying tables.

WHEAT VARIETY TRIALS CONDUCTED ON RESEARCH STATIONS, 1942.

Maturity.	Variety.	CHAPMAN RESEARCH STATION. 1942 Season. Varietal Yield per Acre.	CHAPMAN 1942 Season. Yield per Acre adjacent Nabawa Control.	CHAPMAN 1942 Season. Percentage of Control.	CHAPMAN Average. Over Period Percentage (Years in brackets).	AVONDALE RESEARCH STATION. 1942 Season. Varietal Yield per Acre.	AVONDALE 1942 Season. Yield per Acre adjacent Bencubbin Control.	AVONDALE 1942 Season. Percentage of Control.	AVONDALE Average. Over Period Percentage (Years in brackets).	SALMON GUMS RESEARCH STATION. 1942 Season. Varietal Yield per Acre.	SALMON GUMS 1942 Season. Yield per Acre adjacent Nabawa Control.	SALMON GUMS 1942 Season. Percentage of Control.	SALMON GUMS Average. Over Period Percentage (Years in brackets).
		bus. lb.	bus. lb.	%	%	bus. lb.	bus. lb.	%	%	bus. lb.	bus. lb.	%	%
Late	Fedweb	9 31	8 31	112	105 (5)	17 20	25 0	69	76 (2)	28 6	27 34	102	97 (3)
	Kondut	9 43	9 19	104	107 (5)	24 42	24 22	101	95 (2)	28 4	28 28	99	96 (3)
Mid-Season	Bencubbin	10 46	9 19	115	117 (6)		Control			31 50	28 28	112	113 (3)
	Eureka II.	5 55	7 0	85	106 (2)	19 48	25 0	79	.	27 40	27 34	100	100 (1)
	Ford	7 59	7 0	114	102 (6)	22 12	24 22	91	....		..	.	90 (2)
	Nabawa		Control			...	..	..	...		Control		
	Warigo	9 14	8 31	108	108 (1)	....	....	....	...		...	.	...
Early	Eureka I.	10 18	10 2	103	103 (2)	23 18	25 45	90	....	....		.	
	Gluyas Early ..	...	....	..	..	...	..	..	...	25 10	26 28	95	96 (2)
	Koorda	9 6	11 15	81	108 (5)	18 54	26 57	70	82 (2)	30 40	26 28	116	108 (3)
	Merredin	8 50	11 15	78	97 (4)	21 18	26 57	79	94 (2)	..	...	...	97 (2)
Very Early ...	Bungulla	11 4	10 2	110	113 (4)	27 30	25 45	107	102 (2)	28 16	26 18	107	106 (3)
	Noongaar	.	..	..	..	..	..		.	23 2	26 18	88	88 (1)
		Planted .. Germinated ...	15th May 20th May. Bencubbin Eureka II. Fedweb Kondut Ford Warigo	4th June. 11th June. Eureka I. Koorda Merredin Bungulla		Planted . Germinated ..	5th May. 25th May. Eureka II. Fedweb Kondut Ford	25th May. 4th June. Merredin Koorda Bungulla Eureka I.		Planted .. Germinated .	15th May. 20th May. Bencubbin Eureka II. Fedweb Kondut	30th May. 7th June. Bungulla Gluyas Early Koorda Noongaar	

WHEAT VARIETY TRIALS CONDUCTED ON RESEARCH STATIONS, 1942—continued.

Maturity.	Variety.	MERREDIN RESEARCH STATION. 1942 Season. Varietal Yield per Acre.	MERREDIN 1942 Season. Yield per Acre adjacent Bencubbin Control.	MERREDIN 1942 Season. Percentage of Control.	MERREDIN Average for Period. 1941–42 Bencubbin Control.	MERREDIN Average for Period. Ending 1939 Nabawa Control. *	WONGAN HILLS RESEARCH STATION 1942 Season. Varietal Yield per Acre.	WONGAN HILLS 1942 Season. Yield per Acre adjacent Bencubbin Control.	WONGAN HILLS 1942 Season. Percentage of Control.	WONGAN HILLS Average for Period. 1941–42 Bencubbin Control.	WONGAN HILLS Average for Period. Ending 1940 Nabawa Control. *
		bus. lb.	bus. lb.	%	%	%	bus. lb.	bus. lb.	%	%	%
											113 (2) April
Late	Kondut	25 26	27 46	92	91	..		.	.	86 (1941)	109 (3) May
											108 (9) April
	Sutton	...	..		.	74 (3) April	..		.	76 (1941)	97 (7) May
											102 (9) April
	Yandilla King	...	..	...		77 (6) April	..	.			92 (9) May
	Fedweb	...				73 (1) April		.		66 (1941)	95 (2) May
						113 (10) April					112 (10) April
Mid-Season	Bencubbin		Control			112 (10) May		Control			112 (10) May
						114 (9) June					105 (10) June
	Nabawa	..	.		90 (1)	Control	.			74 (1941)	Control
						80 (1) April					92 (2) April
	Ford	..				27 (1) May	.	..			92 (2) May
	Eureka II.	22 35	27 46	81	81 (1)	.					
						82 (4) April					95 (9) April
Early	Gluyas Early ..	21 34	25 20	85	77	108 (11) May				81 (1941)	95 (10) May
						112 (10) June					98 (10) June
											91 (10) May
	Merredin	...	.		..	101 (9) June	15 4	21 4	72	81	91 (9) June
						93 (3) April					
	Totadgin . .	.			.	115 (8) May	.				88 (6) May
						120 (7) June					84 (6) June
	Koorda . ..	20 3	25 20	79	81	105 (1) June	16 42	21 4	79	91	107 (3)
Very Early	Bungulla ..	23 31	24 43	95	91	131 (3) June	19 46	19 34	101	104	90 (2)
						104 (11) May					102 (9) May
	Noongaar .. .	23 9	24 43	94	92	120 (11) June	13 12	19 34	67	71	88 (12) June
						95 (10) May					88 (9) May
	Geeralying .. .	.		..	.	101 (10) June					88 (8) June
						82 (4) April					
Premium Varieties	Carrabin	...		..		91 (3) May				.	100 (11) May
						97 (8) June					94 (11) June
	Comeback ...	16 22	28 2	58	55	63 (3) May	12 34	20 22	62	63	
						97 (2) May					91 (9) May
	S.H.J.					88 (8) June					90 (9) June
	Pusa IV. ..	21 50	28 2	78	79	95 (3) May	12 24	20 22	61	73	97 (1)

* Years in brackets, and month of planting.

Merredin Research Station:

Planted ..	9th May.	28th May.
Germinated .	18th May.	7th June.
	Kondut	Gluyas Early
	Eureka II.	Koorda
	Comeback	Noongaar
	Pusa IV.	Bungulla

Wongan Hills Research Station:

Planted	9th to 11th June.	
Germinated		
	Noongaar	Merredin
	Bungulla	Comeback
	Koorda	Pusa IV.
Planted	17th April, 1941	15th May, 1941.
	Sutton Nabawa	Gluyas Early
	Kondut Fedweb	

Farmers' field trials were conducted at Northampton on Messrs. Drage Bros. and K. Williams' properties. The results of these trials which were conducted under conditions of ample winter rainfall are as under. Both properties are located west of Northampton.

The following shows the monthly rainfall registrations of rain at Northampton during 1942:—

Year.	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
1942 ..	9	24	11	99	412	383	243	246	137	88	1,509	.		1,652

—	Mr. K. Williams			Messrs. Drage Bros.		
	Yield per Acre.		Percentage Adjacent Nabawa Control.	1942.		1941.
	Varietal.	Adjacent Nabawa Control.		Yield per Acre.	Percentage Bencubbin Control.	Percentage Bencubbin Control.
	bus. lbs.	bus. lbs.		bus. lbs.		
Bencubbin	31 47	29 25	108	13 15	100	100
Eureka II.	33 47	29 25	115	13 1	98	...
Fedweb	26 19	29 20	90	9 44	73	83
Ford	... ...	... ...	...	11 31	86	97
Nabawa	Control	... ...	100	12 14	92	93
Kondut	31 31	29 20	107	12 5	91	97
Sutton	... ...	... ...	...	9 30	71	90

OATS.

The grain yield of the leading oat varieties when sown on fallow was determined during 1942 at three Research Stations. The planting of these trials on fallow not only reveals the relative grain yielding capacity of the varieties under test, but also gives valuable data on their straw strength.

The need for improving the straw strength and grain holding capacity of oats is widely recognised and the new crossbred Ballidu, because of its superiority in these respects, must be regarded as a suitable alternative to the leading early variety, Mulga. Ballidu was bred on the light soil of the Wongan Hills Research Station by D. R. Bateman. It matures at about the same time as Mulga, against which it has been tested for two years at the Merredin Research Station and for three years at the Wongan Hills Research Station. In all five trials, which were notable for the favourable pre harvest weather, Ballidu gave superior grain yields. At the Salmon Gums Research Station during 1942, a severe storm occurred just as the early varieties were maturing. Because of the relatively minor damage suffered by the Ballidu in this storm, it outyielded Mulga by a much greater margin than is usual.

Satisfactory grain yields have been given by the new late mid-season variety Dale. This variety has a similar history to Ballidu and was bred to meet the demand for a variety which would mature earlier than Algerian and possess stronger straw than Guyra.

The variety Wongan released some years ago is proving very satisfactory and is increasing in popularity particularly in the northern cereal growing districts. It is very early maturing and consequently should be among the later planted varieties unless it is to be grazed during the winter.

Details of the yields are set out in the accompanying table.

OAT VARIETY TRIALS CONDUCTED ON RESEARCH STATIONS, 1942.

Maturity.	Variety.	MERREDIN RESEARCH STATION.					WONGAN HILLS RESEARCH STATION.					SALMON GUMS RESEARCH STATION.		
		1942 Season.			Average for Period.		1942 Season.			Average for Period.		1942 Season.		
		Varietal Yield per Acre.	Yield per Acre adjacent Guyra Control.	Per-centage of Control.	1941–42 Guyra Control.	To 1938 Per-centage of Mulga Control.	Varietal Yield per Acre.	Yield per Acre adjacent Guyra Control.	Per-centage of Control.	1941–42 Guyra Control.	To 1940 Percentage of Burt's Early Control.	Varietal Yield per Acre.	Yield per Acre adjacent Guyra Control.	Per-centage of Control.
		bus. lb.	bus. lb.	%	%	%	bus. lb.	bus. lb.	%	%	%	bus. lb.	bus. lb.	%
Late	Algerian	...	...	....	..	..	17 0	17 3	100	102 (7)	116 (11)	..	..	....
Mid-Season	Dale ...	34 0	30 24	111	102 (2)	..	16 10	17 3	95	93 (2)	123 (3)	13 24	15 32	86
	Guyra ...		Control			93 (7)		Control			107 (11)		Control	
Early	Burt's Early	....	....	....	...	91 (4)	...	..	....	..	Control	...	....	...
	Mulga	36 32	28 16	129	115 (2)	Control	16 19	16 21	100	92 (2)	93 (11)	8 18	15 39	53
	Ballidu ...	41 32	28 16	147	133 (2)	...	19 6	16 21	116	118 (2)	97 (1)	15 30	15 32	100
Very Early	Wongan	35 32	30 24	117	110 (2)	73 (2)	14 32	15 32	94	79 (2)	114 (5)	9 2	15 39	57
	Palestine	....	...	....	....	95 (5)	....	.	...	...	110 (4)	.	..	...
		Planted on 12th May. Germinated on 25th May.					Planted on 17th June. Germinated on 27th June.					Planted on 14th May. Germinated on 20th May.		

Oat Grazing and Recovery Trial—Avondale Research Station, 1942.

I. THOMAS, Superintendent of Wheat Farming, and
A. J. MILLINGTON, Field Technician.

The ability of cereals to give substantial winter and spring grazing and to later mature satisfactory grain yields varies considerably with both the variety grown and the season. An experiment to evaluate five oat varieties for their ability to yield both green grazing and grain was conducted at the Avondale Research Station during 1941 and again, with the addition of Atlas barley, during 1942. The season opened much earlier in 1942 and good weed control was obtained prior to planting on fallow on April 14th. Germination, however, did not occur until after the mid-May rains. Growth was very rapid and by mid-June when the first grazing was made, the plots of all the varieties except Fulghum were about 6-8 in. high. The plots after sampling, were grazed to a uniform sward on 11th June and again on 14th July after the second sampling. The crop was then allowed to mature and the grain harvested.

	First Grazing.*		Second Grazing.*		Grain Yield.		Mean Yields, 1941–42.		
——	23-6-41.	11-6-42.	24-7-41.	14-7-42.	1941.	1942.	First Grazing.*	Second Grazing.*	Grain.
	cwt. per acre.	cwt. per acre.	cwt. per acre.	cwt. per acre.	bus. per acre.	bus. per acre.	cwt. per acre.	cwt. per acre.	bus. per acre.
Ballidu	6·1	12·8	7·0	11·1	6·7	32·8	9·5	9·1	19·8
Dale	5·7	12·5	7·5	11·1	5·6	29·9	9·1	9·3	17·8
Fulghum ...	5·9	10·8	8·2	10·1	9·1	25·7	8·3	9·2	17·4
Wongan ...	6·5	14·4	6·8	11·7	3·3	21·7	10·5	9·3	12·5
Mulga	5·7	11·5	6·3	10·2	2·2	19·3	8·6	8·2	11·2
Atlas	...	15·0	...	10·5	...	†21·9	...	...	...
Significant Difference (P = ·05)	0·42	0·7	0·58	Not Signif.	1·4	3·2	...	...	...

* On a moisture free basis. For dry green fodder weight add 10–15 per cent. † 50 lbs. per bushel.

The best return in the 1942 trial was given by Ballidu, a new early maturing variety bred by D. R. Bateman at the Wongan Hills Research Station. The yield obtained from Ballidu was about 26 cwt. of air dry green fodder and 32.8 bushels of grain per acre. These yields are greatly superior to those of Mulga. Ballidu is much more leafy than Mulga and not as sensitive to injury by grazing. In addition to its prolific grain yields it is particularly notable for its strong straw and good standing qualities in adverse weather.

The variety Fulghum has a very long leafy growth phase which makes it ideal for grazing in the early spring. In trials such as the above where grazings are made as soon as one of the varieties included is sufficiently advanced, Fulghum, because of its slow initial growth, is at a disadvantage. Nevertheless it gave 20.9 cwt. of dry material and 25.7 bushels of grain per acre. It must be regarded as an oat to provide early spring rather than winter grazing which can be better supplied by the general purpose oats such as Ballidu or six-row barleys such as Atlas. The rather poor recovery of Atlas barley after the first grazing was due in

some measure to its being severely attacked by the fungus, powdery mildew. The very wet winter no doubt favoured this disease which did not attack the oat varieties to an appreciable extent.

In view of the dry weather in late spring, the yield of the late mid-season oat Dale, was very satisfactory. Wongan yielded well at the first grazing and should be valuable for grazing and recovery in drier districts where the shorter growing season would permit of only one grazing.

The highly nutritious nature of the growing cereal crop is widely recognised and its value in the production of fat lambs clearly demonstrated by other experiments at the Avondale Research Station.

Book Review.

"AUSTRALIA'S DYING HEART."

By JOCK H. PICK.

Melbourne University Press 3s.

The author of this small book of 90 pages was brought up in the inland of South Australia as a pastoralist. His book is the result of long experience in the inland of this portion of Australia combined with keen observation and study and its compilation was prompted by the recognition of the urgency of the need for a national policy of active conservation measures.

He briefly reviews the factors associated with soil erosion problems and the occurrence of deserts in various parts of the world, and with this as a background directs his attention to the situation in Australia. While Mr. Pick briefly mentions the ravages of soil erosion in the wetter and more productive agricultural districts, his main attention is focussed on the salt bush—blue bush country of the inland areas receiving an average annual rainfall of less than 10 inches. Here the problem has become acute and is quite distinct from that of any other part of the Commonwealth. His observations apply particularly to portions of South Australia, New South Wales and Queensland and only in principle to Western Australia, concerning which he appears to have had little information.

The author draws attention to soil erosion as the result of the upset of the delicate balance of nature established before the occupation by the white man and gives evidence of the damage inflicted by overstocking and the depredations of vermin such as the rabbit, in bringing about the destruction of the perennial shrub cover. As much as 90 per cent. of the salt bush and blue bush has been destroyed in some parts and the resultant exposure of the soil to the elements has been disastrous.

Of particular interest are the suggestions made by Mr. Pick for alleviation and rehabilitation. He recommends a more stable and wise system of land tenure coupled with appropriate taxation and fiscal policy, the removal of the incentive to overstocking, unremitting efforts to control the rabbit menace and the formation of a Federal Soil Conservation Service, generously staffed and financed, and with wide powers for constructive and educative action.

It is a stimulating and readable book drawing attention to a major national need for future reconstruction work. Perhaps the chief criticism of the book is that its brief mention of the subject fails to give proper perspective to the more serious and more insidious damage being suffered by the more productive agricultural lands of the higher rainfall areas where conservation measures are just as urgently needed.

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The Urgent Need for Increased Production.

M. CULLITY, Superintendent of Dairying.

DAIRY PRODUCE.

Considerable attention has been directed in recent months to the need for increasing the output of all forms of dairy produce. This increased production is needed for export to Great Britain to help fill the gap caused by the loss of European sources of supply and by decreased exports from the Dominions, and which has meant a great reduction in the amount of butter available to her population. Rising consumption within Australia, combined with decreasing production, makes the problem urgent.

The Australian dairy farmer has been asked to play his part by maintaining or, if possible, increasing the output from his farm.

He has experienced many difficulties which have been disheartening and while efforts are being made to find solutions to the problems of labour and equipment, he is asked to continue his operations to the best of his ability. Each is asked to set a target of production for his own farm so that a definite objective will be in view and arrangements made to attain it.

It is suggested that in addition to the normal activities which might be included under the general heading of efficient dairy husbandry—which would include the use of good cows mated to proved bulls, the rearing in a proper manner of the best heifers, adequate feeding, etc.—particular attention should be directed towards the following points which are considered to offer the greatest opportunity of increasing production:—

1. *Size of Herds.*

Herds should be maintained at the maximum size permitted by the condition of the property and the facilities available for milking. The number of cows must bear relation to the amount of pasture available as over-stocking must be avoided. It is far better to have a few cows under capacity on a farm than to have one or two too many. In the case where a number of young stock are kept, the owner

should consider the advisability of reducing the number to a bare sufficiency for replenishing his herd so as to enable him to increase the actual number of cows that can be carried.

2. *Top-dressing.*

While reduced quantities of superphosphate are available, as a general rule, it is advised that it should be spread evenly over all paddocks each year. In the newer districts particularly, it is advisable to do this, as otherwise too great a deterioration of the clover pastures, in the areas lightly dressed or left not top-dressed, would occur.

Fortunately for the year 1943-44 an increased ration of super will be allowed for dairy pastures which will be approximately 75 per cent. of the normal usage. It is expected that farmers will take full advantage of this special allowance which is intended to assist them in increasing production.

3. *Early Calving.*

Mating cows to calve during the period from the end of March to the end July will allow the cows to produce more than if they calve at any other period of the year. The average production per cow according to the month of calving for 36,986 lactations is shown in the accompanying graph. (Page 172, Jnl. Agric., Sept., 1941.) There is no doubt that this aspect of the management of a herd holds one of the greatest possible opportunities for increasing production.

4. *Feed.*

When arrangements have been made to bring the cows in early, it is essential that a sufficient supply of feed be available for use prior to calving and to supplement the pasture until the spring growth commences. This can be obtained by conserving an adequate quantity of hay and silage and may be supplemented by the growing of an early oat crop. Labour difficulties may prevent the individual farmer from harvesting as much hay or silage as he normally would and these may be best overcome if farmers arranged themselves into small groups which would assist one another in cutting and carting the hay on their various farms.

The effect of having plentiful feed is particularly well demonstrated during the present season as the early rains have caused the growth of pasture which has enabled the output of dairy produce in April and May to be more than thirty per cent. higher than in April and May of 1942. In normal seasons this production could be achieved by having an adequate quantity of conserved fodder which would be utilised for feeding cows nearing calving and for those which had already commenced their lactations.

The feeding of dairy cows approaching calving is most important as during that period it is essential for the cow to be provided with adequate supplies of good feed in order to be in a position to meet the demands of her unborn calf.

If this feed is not provided in sufficient quantities the result will be that the cow will be in a poor condition when she calves and will then necessarily devote her energies during the subsequent three months to building herself up, whereas had she been in good condition at calving time this energy would have been devoted to producing milk, thus increasing her total production.

A plentiful supply of hay will also allow pastures to be shut up at the commencement of the season, so that the plants can make good growth and root development before being grazed.

PIG MEATS.

A similar position to that described for Dairy Produce exists for pig-meat. The increased population in Australia naturally has created a higher demand, and coupled to this is the fact that our American Allies consume a greater amount of pig-meat than we do. Certain commitments to Great Britain also have been undertaken and the effort to fulfil these is a matter requiring the special attention of pig raisers. To do this Western Australia had to produce more pigs than ever before.

The recently announced pig purchase plan guarantees that pigs will be purchased at satisfactory prices for at least the next two years.

Success in increasing production could be achieved by the adoption of the following points:—

1. *Maximum Herd Size.*—The number of sows which are kept should be increased to the limit of the manpower available.

2. Breeding stock of good type and from a prolific strain should be selected.

3. Sows should be mated to farrow frequently: two litters per year are possible.

4. In the grain-growing areas, a mixture of wheat and meat-meal in the proportion of 9 : 1 should be fed, using two per cent. ground limestone or bone-meal. After the pigs reach about 100 lb. deadweight, 10 per cent, cereal chaff should be added to the mixture in order to slow down the rate for deposition of fat while the animal is still growing.

5. In the dairying areas the skim milk available should be supplemented with grain in order to feed more pigs. In addition to one gallon of milk, 1 lb. of grain should be used for each month of age over two months.

6. Wheat is available from the Wheat Board, through its brokers, the Trustees of the Western Australian Wheat Pool, at a price of 3s. 6½d. per bushel in bags at Bunbury or Geraldton, or 3s. 3½d. in bulk at Picton and Fremantle. These prices are for truck lots and where individual farmers are unable to finance this quantity, a group of farmers could arrange to share one order.

Occasionally inferior wheat, but still suitable for feeding, is available at lower prices.

7. Light weight or unfinished pigs should not be marketed.

The Argentine Ant.

(Iridomyrmex humilis. Mayr.).

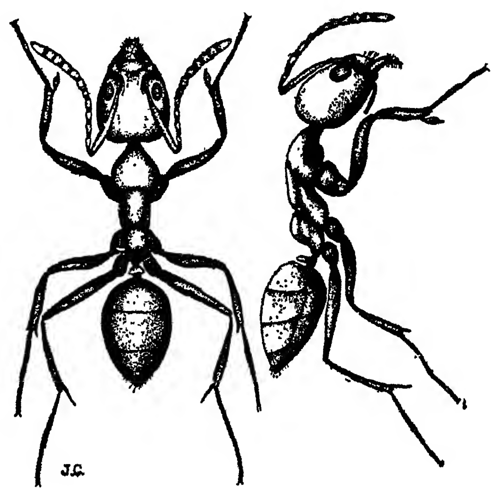
A NEW PEST IN WESTERN AUSTRALIA.

C. F. H. JENKINS, Government Entomologist.

The native home of this ant, as its name implies, is believed to be the Argentine Republic. It is recorded, however, from other South American countries. and has been introduced into the United States of America, where it is reported to be still spreading. It is now established in many countries of the world and on the island of Madeira is said to have been so successful as to have supplanted completely all the native ants on the island. It was known in South Africa as long ago as 1908, and it still remains a serious pest in that country.

The first record of the ant in Australia came from Victoria in September, 1939. It was not long, however, before the pest was located in Western Australia, the original specimens being sent to the Department for Agriculture for identification by residents of Albany in April, 1941.

Regulations were immediately gazetted quarantining the affected area, but unfortunately later inspections made in metropolitan districts, showed that the ant had gained a firmer hold than was first suspected. It has now been necessary to prevent the sending, from within a five-mile radius of the Perth Town Hall to other parts of the State, plants in pots or packed in soil except with a permit from the Department of Agriculture.



Argentine Ant Workers.
(After Clark.)

GENERAL DESCRIPTION.

Being social creatures, Argentine Ant colonies contain queens, males, and workers. It is the workers which are most commonly seen, and whose presence cause the actual trouble. In size they resemble very closely a number of other common house ants measuring about ⅛ of an inch in length. They are a uniform honey brown in colour, and do not give off the formic acid smell so characteristic of most ants when crushed. This is not an infallible means of identification, however, as other local ants are also characterised by this lack of odour.

The winged male ants are seldom seen, but are somewhat larger than the workers. The virgin queens are winged and are also larger than the workers. When saddled with the responsibility of maintaining the population numbers of a colony they grow still more, due to the increase in the size of the egg-distended abdomen, and shed their wings.

LIFE HISTORY AND HABITS.

The size of ant colonies may vary considerably, containing from dozens to thousands of individuals, and the number of queens present may vary from one to a hundred.

The full details of the life history have not been worked out locally, but in America the ant has been exhaustively studied. It has been found that after the appearance of winged males and females in the nest a nuptial flight may or may

An orange tree showing effects of three years' exposure to Argentine Ant infestation.
(From U.S. Dept. Agric.)

not follow. In either case the females, after becoming fertile, lose their wings and commence egg laying. They may lay 30 or more eggs a day, and live for several years. Most of the eggs develop into worker ants, but at certain seasons males and queens also appear. Like most ants the individuals of this species are great

foragers. Strong trails of the insects will travel considerable distances in search of food, invade houses, or swarm over trees and other objects where suitable attractions are to be found. So strong is their colonising ability that other ant species often find it difficult or impossible to survive where the Argentine Ant is well established.

MEANS OF DISPERSAL.

The fact that nuptial flights are not the regular habit of this ant, and that in some countries the females have not been seen to fly at all means that the natural dispersal of the pest is very slow. It is mainly by artificial means that the insects have been spread about the world, and here again is an important point to note. In order for the species to establish itself a whole colony containing at least one fertile queen must be transported. It is not enough to carry large numbers of workers to a fresh district. These may survive for a long time, but they would not be able to reproduce.

It will now be clear why strict quarantine regulations are passed preventing the removal of plants in pots and soil from infested areas, for by such means a whole colony may easily be carried. It is a common habit of the ant to establish itself in seed boxes or pot plants or even debris and leaves associated with plants. It is by no means only in plants, however, that the insects can be spread, for colonies may make their way into old packing cases and similar refuges, but infested nursery stocks are generally considered to be the most dangerous sources of dispersal.

TYPE OF DAMAGE CAUSED.

Besides being a domestic menace, the ant is a serious orchard pest and it is as such that it is mainly feared.

Injury is not actually caused by the ant itself, but the creatures are greatly attracted by the honey-dew given off by scale insects, aphides, and mealy bugs, and so heavily infest trees carrying these pests. The swarms of ants running hither and thither over the twigs and branches prevent ladybirds, parasitic wasps, and other useful insects from exerting their normal control, and furthermore the actual attention from the ants causes more honey-dew than usual to be excreted. Consequently fruit and foliage is soon covered with the dirty sooty mould fungus associated with insect honey-dew, and the scale or aphis population rapidly rises with consequent detrimental effects upon the trees.

Fortunately, as far as is known, no orchard districts have been yet infested in Western Australia, but in California and South Africa the control of such pests as mealy bugs and red scale is largely dependent upon whether the Argentine Ant can first be subjugated.

As a Household Pest.

The Argentine Ant is practically omnivorous in its taste, attacking sweets such as sugar or honey and cooked meat or bones with almost equal readiness. Its persistence is unequalled by any other species, and at times houses have even been vacated on account of the persecution of this insect.

CONTROL.

The first essential in controlling ants as household pests is to see that no crumbs or particles of food are left about to attract the insects. Despite all efforts, however, more direct action is often necessary and circumstances determine just what method may be used most effectively.

Small colony of Argentine Ants.

(From U.S. Dept. Agric.).

Fumigation.

When it is possible to find the ants' nests by tracing along the trail of workers, the entire colony may be destroyed by pouring into the hole a couple of tablespoonfuls of carbon bisulphide. Where several holes are present all should

be treated and the openings blocked with moist earth to prevent the escape of the heavy gas generated. Carbon bisulphide is explosive and inflammable, and so should be used with care.

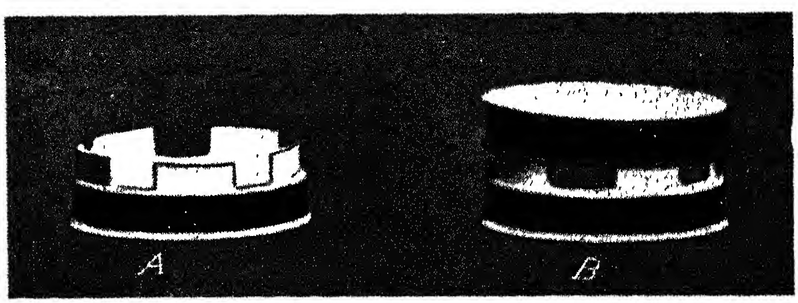
A liberal sprinkling of calcium cyanide dust into the hole if the entrance is subsequently blocked will also be found effective.

Poison Dusts.

Many types of powder are used against ants with varying degrees of success. One of the most useful is powdered sodium fluoride, but powdered arsenic, sheep dip (containing arsenic), Paris green and sodium fluosilicate are useful. The powders should be sprinkled about in places frequented by the ants and liberally sprinkled into and around the entrance to their nests. The efficiency of powders depends upon their being finely ground and dry, for the tiny particles cling to the legs and body of the workers and are eaten in subsequent cleaning and grooming operations, as well as being fed to the queen and other occupants of the nest. Ant eradication by this means is a long process, but it is only by patience and persistent treatment that the pest usually is overcome.

Argentine Ant Bait.

Unfortunately ants are very sensitive indeed to poisons and many baits are taken for a short time and then entirely ignored. On this account it is quite impossible to prescribe a universal ant bait. A formula which has been satisfactorily used, however, against the Argentine Ant in many countries as well as locally is prepared as follows:—Sugar, 1 lb.; tartaric acid, crystallised, 10.3 grains; benzoate of soda, 14.6 grains; sodium arsenite (chemically pure), 26 grains; water, 5-6ths pint; honey, 2 1-3 oz.



Bait Tin.
A, Showing method of cutting sides; B, Lid in place and tin ready for use.
(From U.S. Dept. Agric.)

The water should be warmed in a clean vessel over a low fire. When it is tepid, the tartaric acid, benzoate of soda, and the sugar (slowly) should be added. The mixture must be stirred constantly to prevent burning. The depth of the liquid in the vessel should be measured with a stick. Then bring the mixture slowly to the boil and allow to simmer for 30 to 40 minutes. Remove from the stove and add water to the original depth on the measuring stick to make up for evaporation. The honey should then be stirred in before the mixture cools and the sodium arsenite, which has been dissolved in 1.8 fluid oz. of hot water and partially cooled, poured into the syrup.

The foregoing preparation is on the local market as a proprietary line, and is sold under the name of Argentine Ant poison.

Other Formulae.

(1) $1\frac{1}{2}$ lb. sugar or honey.
2 pints water.
31 grains arsenite of soda (equal to a moderately heaped penny).

Dissolve the sugar in warm water, then add arsenite of soda, stirring well.

(2) For meat and fat eating ants the following bait may be tried:—
Fat, $1\frac{1}{2}$ breakfast cups.
Arsenite of soda, 5 grains (moderately heaped threepenny bit).

Warm the fat and stir in the poison. Bacon rind with a little poison rubbed into the fat may also be tried. The danger to animals and children of such baits should be remembered.

Syrup baits are best used in closed tins perforated in such a way that the ants can enter but so that the contents are protected from dogs, children, etc. The bait tins should be filled with syrup and a small piece of sponge, flannel, or other absorbent material may be placed inside to sop up some of the liquid and give the ants some suitable support on which to feed. As many bait tins as possible should be put near ant nests and tracks so that the insects will feed outside and not be attracted to enter the house.

The total destruction of a nest will take time for until the queen and all the developing ants have been fed with the poison some of the insects at least will still be roaming at large.

Readers who have reason to suspect that they are being troubled by the Argentine Ant are asked to forward specimens to the Department of Agriculture for identification.

ACKNOWLEDGMENTS.

The writer is indebted to Mr. J. Clarke, Entomologist in the National Museum, Melbourne, for the identification of various ants collected during the above investigation.

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Red-Legged Earth Mite.

(*Halotydaeus destructor*)

(Tucker).

A SEASONAL REMINDER.

C. F. H. JENKINS, Government Entomologist.

A common pest at this season of the year is the Red-legged Earth Mite, and unless effectively controlled this creature can decimate the most promising batches of vegetable seedlings.

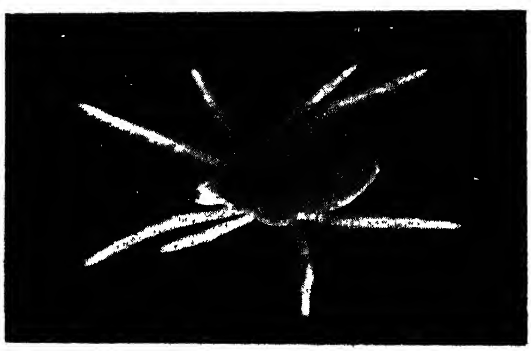
HABITS.

The red-legged earth mite is rather a delicate creature and is very susceptible to dryness, consequently it is only a pest during the winter months. It prefers moist sheltered situations, and thrives especially where such weeds as cape weed are allowed to grow abundantly.

It is mainly on seedlings that the mite's attack is most serious. As soon as the tiny leaves appear the mites swarm upon them and cause them to bleach and wither. The mouth parts of the creature are adapted for rasping or lacerating the plant tissue, and the exuding sap is sucked up. Typical mite injury is indicated by the bleaching and whitening of the attacked foliage, but the absence of actual holes in the leaves distinguishes the injury from the bleaching caused by the lucerne flea, which also attacks pasture plants and many cultivated crops.

The mites are gregarious in habits, often feeding in clusters on a leaf or sheltering together in slight depressions in the ground. When disturbed they scatter in all directions, and if on a plant will usually fall directly to the ground.

The name earth mite is quite apt for the creature, as it seldom goes far from that element, and returns there as quickly as possible at the first sign of trouble.



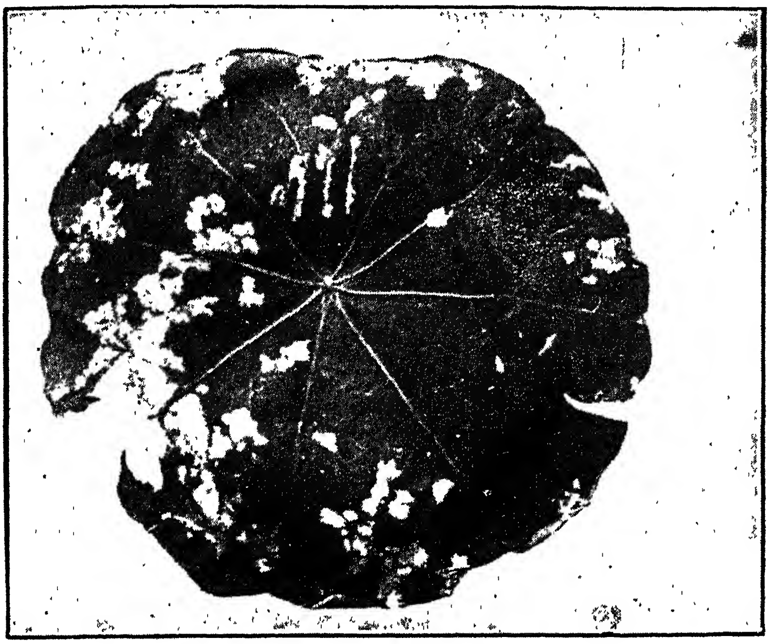
Adult mite, dorsal view, magnified by 20.

CONTROL.

Cultural Methods.—In order to minimise the depredations of this pest all weed growth and especially cape weed plants should be carefully destroyed. If the mites have already appeared for the season, soil to be planted should be turned over and left weed-free if possible for about a fortnight in order to starve out any mites on the plot. Once seeds or young plants have been put in they should be forced along as much as possible by suitable fertilising and watering, for when firmly established many plants can throw off mite injury. If seedlings can be raised early in the autumn before the mite appears, so much the better.

Dusts.—A number of dusts have been tried against this pest with good success, but any artificial treatments must be constantly repeated and will only be successful if combined with suitable cultural methods.

In applying dusts fine weather should be chosen for the treatement whenever possible.



Leaf of plant showing typical injury caused by mite.

Formulae:

1. Tobacco dust, 1 part; slaked lime, 1 part. This dust may be sprinkled on foliage without fear of injury, and is definitely more effective in fine than in cold, damp weather.

2. Fifteen per cent. carbolic powder, 1 lb.; slaked lime or superphosphate, 4 lb. This dust will burn if sprinkled over moist foliage and so should be scattered on the soil around the plants. If some powdered manure is used as a carrier a dual purpose will be served. The carbolic acts as a slight repellent as well as a miticide.

Repellents.

Flaked naphthalene liberally sprinkled over the plants will both kill and repel the mites.

Creosote is a very effective repellent and may be used with advantage to protect small plots. If the plot has a wooden border, or is fenced off with galvanised iron a few inches high, the boundary can be painted with creosote and will effectively prevent the entry of any mites from the outside. Thoroughly saturated wood might remain effective for a month or even longer, and the iron for a week or more. Even if poured on to the soil and left undisturbed, creosote will form an effective barrier for some time.

Sprays.

1. Black Leaf 40, 1½ teaspoonfuls; soap, 1 ounce; water, 1 gallon.
2. Kerosene emulsion used at a dilution of 1 to 8. To mix dissolve ½ lb. of soap in 1 gallon of boiling water. Allow to cool slightly,

and churn in, pouring slowly, 2 gallons of kerosene. This will make a stock solution for keeping which may be diluted as required by thoroughly churning in further warm water.

3. Disinfectant phenyle, 1 part; water, 80 parts. This should be applied with a strong spray, preferably on to the mites on the soil. The foliage should be avoided as much as possible, although at the dilution mentioned burning is not usually serious.

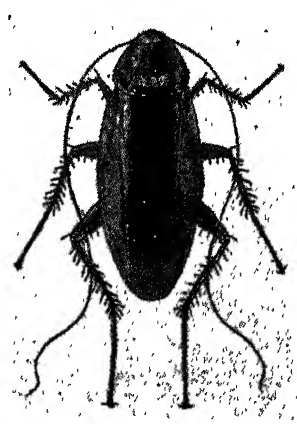
A number of proprietary sprays and dusts are recommended for use against the mite, and several may be used with advantage. It must be remembered, however, that whatever sprays or dusts are used, satisfactory control will only be obtained when repeated treatments are given and when these treatments are combined with clean cultural methods.

Cockroaches, and an Effective Method of Trapping.

C. F. H. JENKINS, Government Entomologist.

Several species of cockroaches are now general household pests. In this country some of the native varieties have become semi-domesticated and, in addition, several introduced forms are to be met with.

The large reddish-brown winged cockroach (*Periplaneta americana* L.) is probably the most universal. It measures about 1½ inches in length and is the largest domestic roach found in this State. Another common species is the much smaller German roach (*Blatella germanica* (L.)), brownish in colour and characterised by the two black stripes on the thorax.



The American Cockroach.
(U.S. Dept. Agric.)

Cockroaches are practically omnivorous but are particularly fond of foodstuffs favoured by man. On this account the insect frequently assumes plague proportions in kitchens and galleys.

LIFE HISTORY.

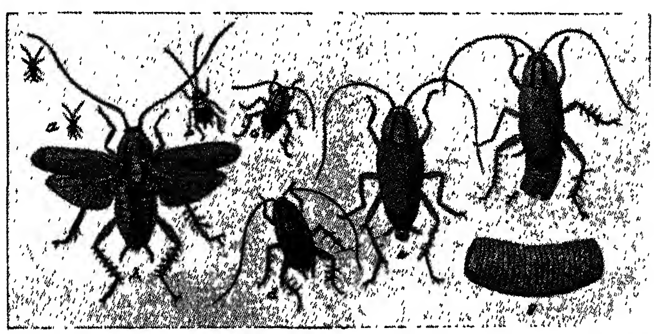
The eggs of the cockroach are developed in a chitinous capsule or packet, which is carried for a time protruding from the abdomen of the female. These capsules may be found attached to rafters, books, boxes, or other rough surfaces. In the case of the American cockroach, attempts may be made to cover the egg capsules with bits of chewed paper, etc.

The young, on hatching, have the general form of the adult. They moult several times and reach maturity after several months.

The exact duration of the different stages varies considerably. For the egg stage 70 days at 77deg. F. has been quoted as the developmental period, but under Australian summer conditions this time is probably reduced. Several months or perhaps a year may elapse before the adult stage is reached. The female may lay a number of capsules, each containing approximately 16 eggs. The longevity of the adults is considerable, for an individual under observation in this laboratory survived for over two years.

RELATIONSHIP TO DISEASE.

On account of its association with offal and scraps of all kinds the cockroach is a potential mechanical carrier of disease. Roaches have been known to eat infected excrement and disgorge infective material some time later.



The German Cockroach: a-d, Immature specimens; e, Male; f, Female with egg case; g, Egg case enlarged.
(U.S. Dept. of Agric.)

CONTROL.

Meticulous care with regard to the disposal of foodstuffs and scraps is the first essential in any attempt to control this pest.

Sprays.—The use of kerosene-pyrethrum fly sprays, where direct contact can be obtained, is effective, but on account of the insects' nocturnal habits this contact is usually difficult to achieve.

Dusts.—The use of various dusts to be sprinkled into cracks and crevices or in situations which the roaches are known to visit, is widely recommended.

Sodium fluoride is the most effective of these dusts and under dry conditions can be thoroughly recommended. Borax is a dust which, although less effective than sodium fluoride, is not poisonous to humans. For ordinary household infes-

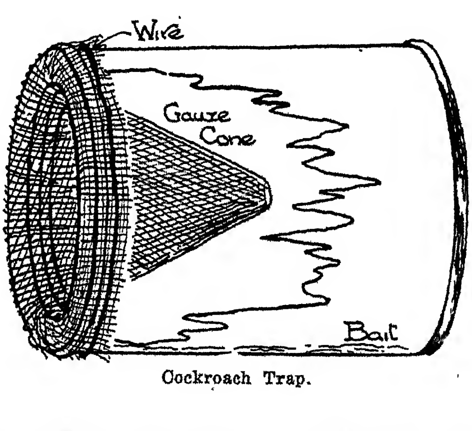
tations, borax and borax and sodium fluoride mixed may be used. The higher the proportion of the latter the more rapid will be the results obtained. Sodium fluosilicate may be used if sodium fluoride is not available.

In order to be effective, dusts must be finely ground and dry. They depend for their efficiency not upon the fact that they are palatable and so eaten by the roaches, but upon the fact that the tiny particles cling to the legs and antennae of the insects and are subsequently swallowed when these members are licked and cleaned in subsequent grooming operations. Dusts containing pyrethrum and derris are also effective, but pyrethrum rapidly deteriorates on exposure to the air and so only fresh dust is effective.

Traps and Baits.—A recently devised trap has proved most effective in catching large quantities of cockroaches for laboratory purposes and should be useful in any infested premises. The trap may be made from a suitable sized tin with a flanged edge, such as is found in press-top treacle tins. The flange enables a small quantity of liquid bait to be retained when the tin is laid in position on its side. A tapering cone of fly-wire is fitted into the tin and a flattened hole about 5/8 inch broad and 3/8 of an inch high is made in the apex of the cone to give the insects free entry. The cone may be held in position by allowing the wire at the base to fold over on to the outside of the tin, where it may be secured by a piece of thin wire.

A neater article may be achieved by cutting almost the entire centre out of the press-top lid and soldering the cone into position. This will enable the trap to be easily dismantled for emptying and cleaning.

Glass screw-top jars shaped so that they retain a little liquid when placed on their side could be used instead of tins, and in the absence of fly-wire, cardboard or metal cones could no doubt be shaped and glued or soldered into place.



Cockroach Trap.

One of the most attractive materials for cockroaches is stale beer, and traps should be baited with a few drops of this liquid before being placed on their side behind stoves, in cupboards, or in other likely situations. The best results so far obtained have followed the use of stale beer, but if this is not available moist apple peelings or water sweetened with treacle or a few food scraps may be tried.

Traps should not be cleaned or washed with strong disinfectant materials, as the smell may act as a repellent to the cockroaches, and reduce the efficiency of the trap.

A bait said to be also very effective is phosphorous rat poison. This should be smeared over the surface of a piece of cardboard, the latter being rolled into a cylinder with the bait on the inside.

It may be noted in conclusion that a widely published bait, employing plaster of Paris, flour, and water has been shown to be founded upon inaccurate observations and should not be relied upon.

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The Cost of Raising Pigs in the Wheat Belt.

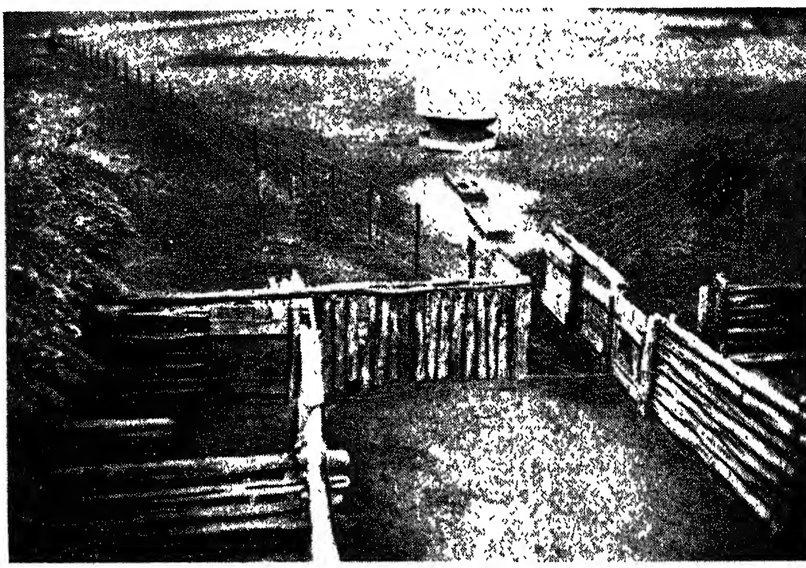
F. V. KNAPP, Agricultural Adviser.

So that information could be obtained as to the costs of feeds and the financial returns of pig raising in the wheatbelt, the writer made arrangements with certain pig raisers to keep full records of their costs and returns for at least one year. It is proposed in this article to deal with the results obtained by Mr. K. Giles, of Doodlakine, for the years 1941 and 1942.

Mr. Giles commenced pig raising during early January, 1941, when he bought three sows in pig, a gilt, and one boar. The three sows were on their second litter. The housing system adopted was of the semi-intensive type; the piggery being divided up into yards (varying in area from four square chain to 10 square chain) and each yard had a breeding pen, half of which was roofed, into which the pigs could be confined when necessary. During the winter months certain of the yards were sown with a cereal for grazing purposes. Just prior to pigging the sow was confined to a breeding pen, and after pigging she and her litter were confined for a further ten days. They were then given the run of the appropriate yard. The young pigs were castrated when about five weeks old and weaned at eight weeks—the sow being placed in with the boar, and the weaners in one of the large yards.

North-west view of yards. Note race at side of feed shed and double roof for coolness. Note sheets of galvanised iron at back and sides of farrowing pen to prevent draughts and consequent pneumonia.

The feeding procedure was as follows: Dry sows and the boar were given grazing supplemented with crushed grain. When no grazing was available they were fed on chaff and crushed grain. From the time of being confined to the breeding pen until weaning the sow and litter were given a ration of approximately 88 per cent. crushed wheat, 10 per cent. meatmeal, and two per cent. lime, supplemented with grazing. After weaning the weaners were given a similar ration, except that as they grew older the percentage of meatmeal was gradually reduced until at the time of marketing they were receiving crushed grain alone. The pigs were fed twice a day, all food being fed dry, but they had access to clean drinking water. During 1941, crushed oats were mixed with the wheat throughout the year in order to use them up.



Looking south from top of feed shed. Note gates leading out into three of the yards. In the foreground may be seen the tap for the central watering trough.

All the pigs were sold at "so much per lb. dressed weight" and 70 per cent. of the liveweight was taken as the dressed weight. Marketing restrictions necessitated that during 1941 all pigs should be marketed at the heavy porker stage, whilst in 1942 they were sold as baconers. In 1941 thirty-six pigs were sold at an average liveweight of 150 lb., the average time from birth to marketing being 165 days. In 1942 fifty pigs were sold at an average liveweight of 167 lb., the average time from birth to marketing being 182 days; in addition to these there were 15 pigs on hand at 31st December, 1942, which could not be marketed before that date for various reasons, the value of these have been taken into account in working out the returns for 1942. To ensure that pigs did not exceed the maximum weights, they were weighed at regular intervals prior to marketing.

During 1941, each sow had two litters, the average number per litter being six, all of which were marketed. However, in 1942, the average number of pigs marketed per litter increased to 9.3.

The returns, food fed, etc., for the years 1941 and 1942 are set out in Tables 1 and 2 respectively.

TABLE 1 (1941).

Food.*	Per Pig Marketed.	Per lb. Liveweight.	Per lb. Dressed Weight.	Per Day.
Wheat	9 bus. 25 lb.	3·77 lb.	5·38 lb.	3·46 lb.
Oats	2 bus. 8 lb.	·59 lb.	·84 lb.	·54 lb.
Total Cereals	653 lb.	4·36 lb.	6·22 lb.	4·00 lb.
Meatmeal	28 lb.	3·00 ozs.	4·27 ozs.	2·70 ozs.
Total Food	681 lb.	4·56 lb.	6·50 lb.	4·13 lb.
Net Returns	£2 13s. 6d.	4·28d.	6·11d.	...
Total Costs	£1 15s. 0d.	2·80d.	4·00d.	...
Profit	18s. 6d.	1·48d.	2·11d.	...

* Includes food fed to sows and boar. Liveweight gain per day of marketed pigs—0·92 lb.

Assuming that the amount of oats eaten had been wheat and excluding labour costs and interest on capital expenditure, the price obtained per bushel of wheat is as follows:—

	£ s. d.
Total net returns	96 4 11
Less value of meatmeal	7 10 0
Value of wheat	88 14 11
Quantity of wheat fed	382 bushels

Value wheat per bushel .. .. .. $\frac{88\ 14\ 11}{382}$

= 4s. 6d.

TABLE 2 (1942).

Food.*	Per Pig Marketable.	Per lb. Liveweight.	Per lb. Dressed Weight.	Per Day.
Wheat	10 bus. 0 lb.	3·90 lb.	5·40 lb.	3·43 lb.
Meatmeal	23 lb.	2·37 ozs.	3·38 ozs.	2·10 ozs.
Total Food	623 lb.	4·00 lb.	5·70 lb.	3·56 lb.
Nett Returns	£3 0s. 0d.	4·82d.	6·85d.	...
Total Costs	£1 13s. 8d.	2·60d.	3·70d.	...
Profit	£1 6s. 4d.	2·00d.	2·90d.	...

* Includes food fed to sows and boar. Liveweight gain per day of marketable pigs—0·89 lb.

Price obtained per bushel of wheat fed:—

$$\frac{\text{Returns less cost of meatmeal}}{\text{Quantity of wheat fed (bus.)}} = \frac{£183\ 0s.\ 8d.}{650}$$

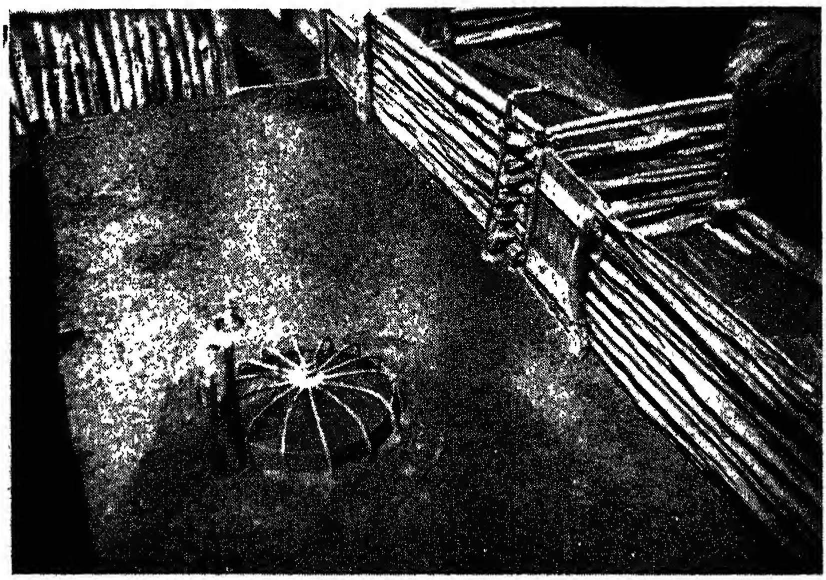
= 5s. 6d.

DISCUSSION.

The average number of pigs marketed per litter (6) in 1941 may appear low, but it must be remembered that the sows were young. From the writer's observations it would appear as though six is about the average number marketed per

litter in the wheatbelt. In 1942 the number marketed per litter had risen to the highly satisfactory figure of 9.3; this increase is partially due to the sows being older and also indicates the good conditions under which the pigs are reared.

Owing to the marketing restrictions, the annual profit per breeding sow in 1941 was only £11; however in 1942, with increased numbers per litter, a raising of the maximum weight for marketing and a slightly better price per pound, the annual profit per sow was £21, an increase of £10 on the figure for 1941. *Of this increase approximately £7 is due to the additional number of pigs per litter marketed,* consequently it is essential for good returns, to obtain highly productive sows and to rear every pig in a litter to marketing stage.



Drinking water trough made so as to prevent pigs getting in it, and placed in passage between farrowing pens. Also shown is the tap for one of the farrowing pens.

A point of particular interest in the tables is the low proportion of high protein concentrate (meatmeal) in the ration fed. As the rate of growth of the pigs was quite fast and the pigs marketed in good condition it is concluded that sufficient protein was available. A large percentage of the protein required must have been supplied in the grazing of cereal crops provided. This is of particular importance to pig raisers in the wheatbelt at the present time, as it points to an alternative supply of protein to meatmeal which is in short supply.

It is interesting to note that in 1942 it took 53 lb. *less* cereal to rear a pig than it did in 1941, and that that pig weighed 17 lb. more. Possibly there was more grazing available in 1942 and also the oats fed in 1941 may not have aided the growing pig to any extent. This, together with increased size of litters, and increased price per lb., has resulted in the value obtained per bushel of wheat fed being increased by 1s. to 5s. 6d. per bushel.

From the results obtained during the two years under review it would appear that a breeding sow having two averaged sized litters per year requires approximately 50 bags of wheat for herself and her two litters per year, providing that she and her litters are given some type of protein concentrate.

South-west view of yards. Note shade trees planted and shelter shed built on to back of each farrowing pen. Fencing comprising ringlock and steel posts, gives satisfactory service.

The results obtained by Mr. K. Giles are very satisfactory from all points of view and are such as could be obtained by other farmers raising pigs in the wheat-belt provided they give their pigs the necessary care and attention.

Thanks are due to Mr. Giles for the excellent manner in which he has kept his records.

Lime in Agriculture.

NOT A SUBSTITUTE FOR SUPERPHOSPHATE.

H. G. CARISS, Agricultural Adviser, and G. H. BURVILL, Assistant Plant Nutrition Officer.

Since Nauru and Ocean Island in the Pacific, and Christmas Island in the Indian Ocean, fell into Japanese hands, the supplies of phosphatic rock for the manufacture of superphosphate in Australia have been considerably curtailed. Less than half of the normal out-put of super is now available, and in addition, because of the lower grade of the rock available, the superphosphate has been reduced in grade from 22 per cent. to 18 per cent. phosphoric acid (P_2O_5).

To obtain the most efficient use of the available superphosphate in the national and individual interests, a rationing scheme is in operation and the amounts allotted for many crops are far below those normally used. In view of these restrictions, farmers are looking for some substitute to make up the deficiency, especially as they feel that crop failures may result from the use of the reduced amounts. The need for superphosphate is very general in Western Australian agriculture. However, where the land has been previously fertilised for a number of years, crop failure is not likely to occur with the smaller dressings, although returns per acre may be reduced somewhat depending on the soil type, seasonal conditions, and the previous history of the area concerned. (Teakle and Cariss (1943).)

From the many inquiries received, it appears that quite a number of farmers are of the opinion that lime is the solution to their problem and that by applying this material they can make up the deficiency in their superphosphate supplies. Lime, however, definitely cannot take the place of superphosphate. It is a source of calcium, the important plant food which is also contained in super, but it does not supply any phosphate (phosphoric acid) which is the most valuable fraction of superphosphate.

Lime is not regarded as a fertiliser in the ordinary sense of the word, but is termed a soil amendment or ameliorator. It is widely used in agriculture in many parts of the world on sour or acid soils to reduce soil acidity, and to effect important changes in the chemical, physical, and biological conditions of the soil. In the agricultural areas of this State soils with an acid reaction are very common and extensive, particularly in the higher rainfall parts, but although many experiments have been carried out over a number of years to test the effect of lime, they have, in general, shown no conclusive benefit. On certain sandy and swampy types in the south coastal districts between Nornalup and Albany, dressings of lime have proved an advantage. There may be other districts where restricted local areas will show similar benefits, but the general use of lime, even on the main pasture soils of our south-west districts which are mostly slightly acid in reaction, cannot be recommended.

When lime is used for soil improvement it is applied either as quick lime, slaked lime or ground limestone. Lime-sand, which is a naturally occurring and finely divided form of carbonate of lime, is available in a number of coastal areas of the State and was available from the Railway Department some years ago from Boranup. Applications of lime are made at rates varying from 5 cwt. up to several tons per acre, and hence it needs to be available at relatively low prices for agricultural use.

It is possible that further investigation may show advantages in the use of lime in this State, for recent scientific research has indicated that some soils which "fix" phosphates very firmly so that they are not easily available to growing plants may release this phosphate for plant growth more readily if they are treated with basic materials such as slaked lime. It is known that only a small part of the phosphate added to our agricultural soils as dressings of superphosphate is absorbed by the crop or pastures. The balance remains "fixed" in the surface soil. After a number of years of cropping or topdressing, this "fixed" residue becomes considerable and experiments are now under way to see if the use of slaked lime can make any of this "fixed" phosphate available.

When both lime and superphosphate are to be applied to the same area it is usually recommended that the two should not be mixed together but that the lime should be applied some time, four to six weeks, prior to applying the super. In some cases, however, mixing may not be a disadvantage, as is shown by the results of an experiment with super-lime mixtures conducted at three centres in the wheatbelt last season and reported by Burvill and Cariss (1943) in this issue. Also, basic super, which is a mixture of about 80 parts of super with 20 parts either of ground limestone or of slaked lime, is used in agriculture and is favoured by some farmers in this State. The amount of lime used in these cases is small compared with dressings normally used to correct soil acidity. Further experiments are being conducted this year at a number of widely separated centres to test the value of various mixtures in which the super may be expected to become reverted to less soluble forms. The mixtures include serpentine superphosphate* from New

*Serpentine super is made by mixing three parts of freshly made superphosphate with one part of ground serpentine rock. Serpentine is a silicate of magnesium, as is also soapstone, and both are closely related to talc.

Zealand and mixtures with ground limestone and powdered soapstone obtained in this State.

As stated earlier, there is no evidence to indicate that the use of lime on pasture and crop lands in this State can be generally recommended. If any farmer wishes to try the effects of lime, strips across a paddock should be treated and intervening strips, carefully pegged and noted, left as check plots. Lime in the form of quick lime, slaked lime, ground limestone or lime sand should be used at varying rates from 5 cwt. to two tons per acre.

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Experiments with Micro-Elements for the Growth of Crops in Western Australia.

VII.—THE EFFECTIVENESS OF VARIOUS TYPES OF COPPER FERTILISERS FOR POTATOES AT BORNHOLM, ALBANY.

By

L. J. H. TEAKLE, and E. T. MORGAN.

SUMMARY.

In view of the widespread demand for copper-containing fertilisers in Western Australia, investigations have been instituted to determine whether copper ore produced locally may be used instead of the refined, granulated bluestone which has proved satisfactory in the past.

The experiments have compared the effects of bluestone, oxidised copper ore, and roaster residues (another copper-containing compound) on the growth of crops on copper deficient soils. That reported below relates to the merits of these substances for the growth of potatoes on a copper deficient semi-swamp at Bornholm, near Albany.

In general, copper-containing fertilisers improve yields. Under the conditions of the experiment, of the three types used, the copper ore proved most effective for the correction of the deficiency. A suitable dressing is of the order of magnitude of 2½ lb. of copper per acre, which is equivalent to 10 lb. of bluestone.

Copper ore can be recommended for general use in the correction of copper deficiency in place of bluestone, except on certain types such as marly soils, which are of restricted distribution in the coastal districts.

1. INTRODUCTION.

Farmers in many parts of Western Australia have become interested in the use of copper-containing fertilisers as a means of improving the growth and quality of crops and pastures. Bluestone, or copper sulphate, containing 25

per cent. copper, has been used most generally in the past, and in 1942, approximately 200 tons were sold for fertiliser purposes in this State. This is a highly refined product and is fairly expensive. On this account, endeavours have been made to secure a substitute obtainable locally at the reduced cost per unit of copper.

To this end, oxidised copper ore from certain mining districts and a by-product of the fertiliser works known as roaster residues, have been tried. The oxidised copper ore generally contains from 10 to 20 per cent. copper and the roaster residues from 1 to 2½ per cent. copper. The roaster residues contain from 2 to 3 per cent zinc.

Experiments and general observations indicate that up to about 10 lb. of bluestone per acre is adequate for most crops and the effect of such a dressing continues over several seasons.

This experiment was designed to determine the relative value of bluestone copper ore and roaster residues supplying equivalent amounts of copper for the growth of potatoes. The oxidised copper ore was obtained from Ravensthorpe and the roaster residues from the Cuming Smith-Mt. Lyell Farmers' Fertilisers Limited works at Bassendean. The area of potato land for the experiment was made available through the courtesy of Mr. R. T. Wolfe of Bornholm.

2. THE SOILS.

The area of semi-swamp land selected for the experiment had been used for the production of potatoes in past years until yields had become very unsatisfactory and tubers showed malformations, such as a type of stem end rot and unusual shapes, which are now associated with copper deficiency. During the last 11 or 12 years the land had been under pasture, of which the chief species was *Lotus major*.

Over the bulk of the area selected for the plots, the soil was of a grey sandy type with calcareous material, probably coastal limesand, in the subsoil. At places the calcareous material appeared at the surface. Five blocks of the experiment were on this type. The remainder of the area was wetter and on this portion the soil may be described as a blackish organic loam. The sixth block of the plots was on this type, which proved very much more productive under the dry conditions prevailing than the more general sandy type.

The chemical properties of these soils are represented by the information in table 1.

TABLE 1.

CHEMICAL COMPOSITION OF SOILS REPRESENTATIVE OF THE PLOTS.

Serial No.	Depth. (ins.)	Description.	pH.	Organic C.	N.	C/N. Ratio.	P_2O_5.	K_2O.
1.—GREY SANDY TYPE—				%	%		%	%
3439	0–10	Grey humous loamy sand	5·31	2·35	·137	17·1	·057	·004
3440	10–18	Dark grey loamy sand	6·56	1·16	·061	19·0	·019	·002
3441	18–26	Khaki brown calcareous sand	7·84	·70	·039	18·0	·009	·002
2.—BLACKISH ORGANIC LOAM—								
3442	0–10	Dark grey humous sandy loam	6·90	8·58	·578	14·8	·161	·012
3443	10–19	Blackish humous loam	6·86	4·88	·314	15·5	·076	·013

The soils are low in essential requirements such as phosphate and potash and nitrogen. The grey sandy type is exceptionally low in these ingredients. There is some evidence of phosphate accumulation in the surface, no doubt due to past superphosphate applications. The blackish, organic loam is also very low in potash but is somewhat richer in phosphate and nitrogen. It shows a similar accumulation of phosphate in the surface layer. The grey sandy soil is moderately acid at the surface but alkaline in the calcareous subsoil. The other soil is approximately neutral.

The moisture relations proved most favourable on the blackish organic loam and under the dry summer conditions prevailing in 1941-42 the growth was very much superior to that on the grey sandy type and the yield was heavy. On the sandy type the crop was much lighter and appeared to suffer from moisture deficiency during the growing period.

The land had been satisfactorily prepared for planting, having been ploughed and twice cultivated with a rotary hoe. For planting, furrows were opened up with a double mould board plough. Round seed supplied from the Denmark Research Station was planted in the furrows with the special fertilisers.

The weather conditions at planting were favourable. During the growing period the rainfall was scanty and much below normal.

The records for Denmark, the nearest Recording Station were as follows:—

Month.	1941–42. points.	General Average. points.
November	131	181
December	35	140
January	146	126
February	45	135
Total	357	582

Only 16 points fell from March 1–9, 1942.

These figures indicate a deficiency of 2¼ inches below that normally expected in the growing period.

Unusually hot winds accentuated the dry weather conditions by accelerating the rate of loss of moisture and caused some damage from sand blast.

The grey sandy soils were less able to stand up to the dry weather conditions than was the blackish organic loam which offered far more favourable moisture conditions.

3. *The Experiment.*

Six treatments were tested in the experiment using a 6 x 6 Latin Square design. As control (Treatment A), potato manure at the rate of 12 cwts. per acre and supplying 40 lbs. of nitrogen, 212 lbs. of P_2O_5 and 64 lbs. of K_2O was used. All other treatments were in addition to this control dressing of potato manure and were as follows:—

Treatment B.—Bluestone 10 lbs. per acre, equivalent to 2.5 lbs. of copper.

Treatment C.—Oxidised copper ore 14 lbs. per acre, equivalent to 2.5 lbs. of copper.

Treatment D.—Oxidised copper ore 28 lbs. per acre, equivalent to 5 lbs. of copper.

Treatment E.—Roaster residues 100 lbs. per acre, equivalent to 2.5 lbs. of copper.

Treatment F.—Roaster residues 200 lbs. per acre, equivalent to 5 lbs. of copper.

These substances were thoroughly mixed with potato manure and spread by hand in the planting furrow with the seed.

It was not possible to make detailed examinations during the growing season but it was observed that the copper treatment generally improved the top growth. The plots receiving no copper showed the usual trailing habit of growth, characteristic of copper deficient soils, and were a marked contrast with the others which were normally erect and vigorous.

When ready to harvest, the potatoes were dug by hand, and the tubers from each plot sorted into first grade and rejects for the determination of yield and quality data.

The results are summarised in Table 2.

TABLE 2.

YIELD OF POTATOES WITH VARIOUS TYPES OF COPPER-CONTAINING FERTILISERS AT BORNHOLM.

Planted—6th November, 1941.
Harvested—9th March, 1942.

Fertiliser.	Yie'ds (tons per Acre).		Percentage of First Grade Tubers.
	First Grade Tubers.	Total.	
A. Control, Potato Manure, 12 cwts. per acre	3·8	5·6	68
B. Potato Manure plus bluestone 10 lbs. per acre ...	4·3	7·2	60
C. Potato Manure plus copper ore 14 lbs. per acre ...	5·7	8·4	68
D. Potato Manure plus copper ore 28 lbs. per acre ...	5·9	8·9	66
E. Potato Manure plus roaster residues 100 lbs. per acre	5·0	7·9	63
F. Potato Manure plus roaster residues 200 lbs. per acre	4·9	7·7	64
Difference for Significance P = ·05	0·91	1·2	...

The general effect of copper in improving the yield of potatoes is brought out by the consideration of the yields of first grade tubers and the total yields. It is difficult to explain why the yield of first grade tubers from the bluestone plots was not significantly better than the potato manure alone. However, the data for the total yield were consistent and indicated a significant improvement with bluestone as well as with other copper-containing fertilisers.

It is of considerable interest that the copper ore has given the best yields throughout. The statistical analysis indicates that it was consistently superior to the bluestone. While this conclusion must be accepted with caution it may be taken to indicate that, on copper deficient soils of this type, the copper ore may be used with confidence in place of bluestone. The roaster residues have proved effective but were not superior to the copper ore.

Small applications of copper are effective. It appears that copper fertilisers equivalent to 2½ lbs. of pure copper per acre are adequate to supply the copper needs; double the rate of application of copper ore and roaster residues did not improve the returns.

The copper treatments appear to have had little effect, in this instance, on the appearance or apparent quality of the potatoes. There were a few specimens of spindle- and crescent-shaped, and pointed tubers and a little evidence of stem end rot throughout the plots, irrespective of treatment. It is thought that the dryness of the season was in large measure responsible for the unsatisfactory shape of some of the tubers produced on a soil of low moisture capacity. Although the proportion of first-grade tubers from the controls was at least equal to that from the plots receiving copper, in general, it seemed that the control plots were most affected. This would indicate that the copper has improved somewhat the capacity of the plants to withstand drought and to secure moisture from the soils under the dry conditions prevailing, an observation which correlates with the known effect of copper fertilisers in improving the rooting systems of plants generally.

The response to copper was confined to the grey sandy soil type. On the blackish organic loam at the south end of the plots, the sixth block produced a good crop—approximately 7½ tons of first-grade potatoes per acre—irrespective of treatment, indicating that on this better class soil there was no apparent response to copper in this first crop after so many years of pasture. It is most likely, however, that continued cropping will induce evidence of copper deficiency on this soil type.

It may be concluded that on the grey sandy semi-swamp land at Bornholm copper deficiency of potatoes occurs and may be corrected by the use of copper-containing fertilisers. Oxidised copper ore has proved very effective and may be used instead of bluestone. An adequate dressing appears to be one which supplies up to 2½ lbs. of pure copper—the equivalent of 10 pounds of bluestone per acre.

It seems that oxidised copper ore may be used very generally for correction of copper deficiency in Western Australia. However, there is evidence that it is of little value on certain types such as the marly swamp soils which occur in restricted areas in coastal regions. On these soils, probably owing to their calcareous nature, observations indicate that bluestone is much more effective.

VIII.—EXPERIMENTS TO DETERMINE THE EFFECTIVENESS OF DIFFERENT SOURCES OF COPPER AND THE RESIDUAL VALUE FOR CEREALS ON COPPER DEFICIENT LAND AT DANDARAGAN AND GINGIN.

L. J. H. TEAKLE.

1.—INTRODUCTION.

Previous papers in this Journal (Teakle, Turton and Throssell, 1940; Teakle, Thomas and Turton, 1941; Teakle, 1942) have given proof of the spectacular effect of copper-containing fertilisers for cereals on one soil type at Dandaragan and have indicated a substantial effect on the typical red sandy red gum country at Dandaragan and Gingin. A variety of copper-containing substances has been

used and all appear to be similar in their effect. Applications of the order of magnitude of 5 to 10 lbs. of bluestone per acre seem to be adequate and equally as effective as heavier dressings. This is equivalent to 1¼ to 2½ lbs. of pure copper per acre.

The investigations here reported are a continuation of those already discussed and consist of seven experiments carried out at Gingin and Dandaragan using oats as the crop in 1941 and wheat in 1942.

The objects included—

(a) The effect of repeating the application of bluestone with subsequent crops.

(b) A further comparison of the effects of bluestone, copper ore, roaster residues, and a line of furnace cinders obtained from Melbourne, supplying a range of amounts of copper.

(c) The effect of copper carbonate pickle on the growth of wheat on acutely copper deficient land.

Six of the experiments were carried out on acutely copper deficient soils on Mr. J. A. V. Brown's property, "Bidgerabbie," Dandaragan. As previously described these soils are light sandy loams containing a large proportion of diatomaceous fragments in the surface horizons. Clay accumulation and diatomite occur in the subsoil layers.

The seventh experiment was on the red sandy or loamy sand soils (grouped as Whakea sands in the Gingin district), on the property of the late Mr. V. G. Rennie, "Moondah," Gingin. On this site the soil ranged from a deep sandy phase of low fertility on the eastern half of the plots, to a stony and gravelly loamy sand phase on the western half, which had proved fairly productive of cereals.

At Dandaragan, on certain of the experiments, there was competition with weeds, of which silver grass and wimmera rye grass were the most serious. Cut worm destroyed portions of the wheat in 1942 on the area used for determination of the effect of copper carbonate pickle.

Wild radish (*Raphanus raphanistrum*) was a serious weed at Gingin.

2.—THE EXPERIMENTS.

These experiments represent the continuation and conclusion of the work commenced in 1939 and reported in the papers mentioned above.

In 1941, one experiment was laid down on the site used in 1939 for the experiment on Mr. Brown's property, Dandaragan, with different rates of bluestone and a micro element mixture. Each plot consisted of two drill widths, so that it was possible to arrange that, in 1941, half of each plot (one drill width) received a repetition of the copper fertiliser used in 1939 and the other half superphosphate only. Mulga oats was selected for the crop. This modification of the layout would give an indication of the residual value of the original copper treatment.

Unfortunately, the oats shed rather badly in 1941 and it was feared that small differences in grain yield due to the differential treatments of the plots might have been obscured. In consequence, these were sown again in 1942, using Ranee wheat and superphosphate only on all plots.

A second experiment on land adjoining this site, which had never received copper in the past, was laid down in 1941, using Mulga oats as the crop and a variety of copper-containing compounds. Bluestone, copper ore, roaster residues,

and a line of copper-containing furnace cinders kindly supplied by Mr. B. Perry of Cuming, Smith and Mt. Lyell Farmers Fertilisers, Limited, Melbourne, were compared with a view to ascertaining the value of copper from different sources when applied at a range of rates of copper. The growth of this area was very satisfactory, but shedding was general and it was thought that differences in appearance of the plots apparent to the eye were not revealed by the harvest yields owing to this trouble. In consequence, this area was sown with Ranee wheat in 1942, using superphosphate only as the fertiliser for each plot.

TABLE I.

Yields of Oats and Wheat on plots established in 1939 *on Mr. J. A. V. Brown's property "Bidgerabbie," Dandaragan. Half of each plot received repetition of the micro-element in* 1941 *and the other half superphosphate only. Superphosphate only was used in* 1942 *on all plots.*

No.	Fertiliser Treatments.			Yield of Grain.		
	Year.	Superphosphate.	Bluestone.	Oats, 1939.*	Oats, 1941.	Ranee Wheat 1942.
		lbs. per acre.	lbs. per acre.	bus. per acre.	bus. per acre.	bus. per acre.
A	1939 ...	112	*nil*	*nil*		
	1941 ...	112	*nil*		9·7	
	1942 ...	70	*nil*			5·9
B (i) ...	1939 ...	112	5	45·5		
	1941 ...	112	5		26·3	
	1942 ...	70	*nil*			12·6
(ii) ...	1939 ...	112	5			
	1941 ...	112	*nil*	...	24·1	
	1942 ...	70	*nil*			13·2
C (i) ...	1939 ...	112	15	45·6		
	1941 ...	112	15		23·8	
	1942 ...	70	*nil*			14·6
(ii) ...	1939 ...	112	15			
	1941 ...	112	*nil*	...	24·5	
	1942 ...	70	*nil*			15·0
D (i) ...	1939 ...	112	30	50·7		
	1941 ...	112	30		24·8	
	1942 ...	70	*nil*			12·4
(ii) ...	1939 ...	112	30			
	1941 ...	112	*nil*	...	26·3	
	1942 ...	70	*nil*			14·3
E (i) ...	1939 ...	112	Mixture†	49·2		
	1941 ...	112	Mixture		25·2	
	1942 ...	70	*nil*			13·0
(ii) ...	1939 ...	112	Mixture			
	1941 ...	112	*nil*	...	26·3	
	1942 ...	70	*nil*			13·7

* Yields given in this column are the composite from both sections of the plots.

† Mixture contained Bluestone (15 lbs. per acre), Manganese Sulphate (15 lbs. per acre), Zinc Sulphate (5 lbs. per acre), Borax (5 lbs. per acre), Iron Sulphate (20 lbs. per acre), and Magnesium Sulphate (20 lbs. per acre.).

TABLE 2.

Yields of Oats in 1940 and of Ranee Wheat in 1942 on plots first planted in 1940 with a range of Copper-containing compounds at various rates. The Copper treatments were applied with Superphosphate in 1940. In 1942 the Wheat was sown with Superphosphate only except on one treatment where Bluestone was again applied.

Treatment.	Yield of Grain.			
	J. A. V. Brown, Dandaragan.		V. G. Rennie, Gingin.	
	Oats, 1940.	Wheat, 1942.	Oats, 1940.	Wheat, 1942.
	bushels per acre.	bushels per acre.	bushels per acre.	bushels per acre.
A. Superphosphate (112 lbs. per acre, 1940; 70 lbs. per acre, 1942)	*nil*	*nil*	17·1	9·2
B. Plus Bluestone (1 lb. per acre, 1940) ...	10·1	4·3	...	...
C. Plus Bluestone (2½ lbs. per acre, 1940) ...	17·0	8·5	...	...
D. (*a*) Plus Bluestone (5 lbs. per acre, 1940)	20·4	9·6	18·8	9·5
(*b*) Plus Bluestone (15 lbs. per acre, 1940)	...	...	21·2	9·9
E. Plus Dissolved Copper Ore equivalent to Bluestone (5 lbs. per acre, 1940)	28·4	10·0	19·6	12·6
F. Plus Dissolved Copper Ore equivalent to Bluestone (15 lbs. per acre, 1940)	31·1	11·6	23·2	11·7
G. Plus Copper Ore equivalent to Bluestone (15 lbs. per acre, 1940)	30·9	12·5	24·8	12·5
H. Plus Roaster residues equivalent to Bluestone (16 lbs. per acre, 1940)	30·1	11·1	19·6*	9·9
J. Plus Bluestone (5 lbs. per acre, 1942), Bluestone only (15 lbs. per acre, 1940)	23·9†	11·1	19·7*†	9·8
K. Plus Cu, Mn, Zn, B, Fe, and Mg in 1940 ...	...	...	16·1	10·7
Difference for Significance P = ·05 ...	3·5	2·6	...	...

* Yield from one plot lost. † No superphosphate in 1940.

The site of the experiment on Mr. Brown's property, sown in 1940, was also cropped in 1942 using Ranee wheat. This experiment included a range of copper-containing compounds and was sown with superphosphate only in 1942, with the exception of one treatment. On this treatment, which had received 15 lbs. of bluestone per acre without any superphosphate in 1940, the wheat was fertilised with a mixture of superphosphate and bluestone. Bluestone was applied at the rate of 5 lbs. per acre with the wheat crop to measure the effect of the additional application of copper in 1942. A similar experiment had been carried out on the late Mr. V. G. Rennie's property, Gingin, in 1940. This site was likewise sown again in 1942 using Nabawa wheat. As in the case of Mr. Brown's experiment, superphosphate only was used on all plots except those which had received bluestone only in 1940. In 1942 the plots under this treatment received superphosphate and bluestone.

To test the effect of copper carbonate pickling a simple experiment was laid down on Mr. Brown's property, adjoining the main blocks of plots. Pickled wheat was sown with and without bluestone as a fertiliser and the growth observed during the season. Unfortunately, web worm (*Sclerobia tritialis*) severely attacked this area and harvest returns could not be obtained. The pickled wheat, however,

suffered severely from copper starvation where sown with superphosphate only. Apparently the copper carbonate pickle had little or no effect in correcting the deficiency under these conditions.

The seasonal conditions in 1941 and 1942 were not as favourable as in 1939 and yields were not high. However, the results have been conclusive and this experimental area will not be continued with as there is evidence of the spread of the effect of the copper treatments to the control plots. Dry autumn weather in 1941 and 1942 at Dandaragan interfered with the preparation of the ground for planting on certain of the experiments and weed control and tilth were not as satisfactory as desirable for experimental work.

On the Gingin plots the light sandy phase gave poor growth, apparently due to nitrogen deficiency which obscured any difference in growth due to fertiliser treatment. The heavier soil phase gave satisfactory crops.

3.—THE RESULTS.

These experiments were harvested by machine at Dandaragan, and at Gingin by cutting drill rows through the plots and thrashing by hand. Grain yields per acre were determined by both methods and the results of the six experiments harvested are tabulated in Tables 1, 2, and 3.

TABLE 3.

Yields of Oats in 1941 and of Ranee Wheat in 1942 on plots first planted in 1941 with a range of Copper-containing compounds at various rates. The Copper treatments were applied in 1941 with the Oat crop. Superphosphate only was applied in 1942 and was used on all plots at the rate of 70 lbs. per acre. In 1941 Superphosphate was used on all plots at the rate of 112 lbs. per acre.

Experiment on Mr. J. A. V. Brown's property, Dandaragan.

Treatment.	Yields.	
	Oats, 1941.	Wheat, 1942.
	bush. per acre.	bush. per acre.
A. Superphosphate only (112 lbs. per acre, 1941; 70 lbs. per acre, 1942)	3·3	*nil*
B. Plus Bluestone (5 lbs. per acre)	29·2	19·0
C. Plus Bluestone (10 lbs. per acre)	28·2	18·9
D. Plus Oxidised Copper Ore equivalent to Bluestone (5 lbs. per acre)	27·6	18·0
E. As D, but equivalent to Bluestone (10 lbs. per acre) ...	27·2	20·2
F. As D, but equivalent to Bluestone (15 lbs. per acre) ...	27·9	18·9
G. Plus Roaster Residues equivalent to Bluestone (5 lbs. per acre)	30·2	17·4
H. As G, but equivalent to Bluestone (10 lbs. per acre) ...	30·9	20·7
J. As G, but equivalent to Bluestone (15 lbs. per acre) ...	28·9	20·5
K. Plus Melbourne Cinders equivalent to Bluestone (10 lbs. per acre)	29·2	19·2
Difference for Significance P = ·05	...	1·6

Study of these data show that with respect to these soil conditions:—

(i) The optimum dressing of copper-containing fertilisers appears to lie between limits equivalent to 5 to 10 lbs. of bluestone per acre. There is some indication that the optimum amount varies slightly with the season and the soil type. Oxidised copper ore, roaster residues, and furnace cinders containing

equivalent amounts of copper appear equally effective with respect to grain yield of oats and wheat. Dressings of 1½ to 2 lbs. of bluestone per acre have proved remarkably effective on the acutely deficient soil at Dandaragan and the effect persists in the second crop. However, these amounts proved inadequate to eliminate the foliar symptoms of copper deficiency or to produce optimal growth and grain yield.

(ii) The effect of the initial dressing of bluestone or other copper fertiliser has persisted over several crops. No advantage in yield of grain has been obtained by repeating the dressing with the second crop and in one case with the third crop of cereals.

It may be noted that the half plots receiving two dressings of bluestone each at the rate of 30 lbs. per acre gave consistently lower yields of wheat in 1942 than the halves receiving only one application of 30 lbs. per acre in 1939. The difference was small and not significant according to statistical treatment, but it may be indicative of possible harmful effects due to the accumulation of copper applied in several dressings at high rates.

Certainly there is no need to use heavy or continuous applications of other copper fertiliser under the conditions investigated at Dandaragan or Gingin. One small dressing will effectively maintain the production of cereal grain for several years. Whether the composition of the pasture will be maintained without annual dressings has to be determined from the results of other experiments already in progress.

(iii) Differences on the red sandy country on Mr. V. G. Rennie's property at Gingin were small. Copper deficiency is not acute on this class of country, but there is no doubt that its copper status is sub-optimal. On the lighter soil phase, where it seemed that nitrogen deficiency obscured fertiliser effects, the growth of the crop was poor and no effect from copper treatment was apparent. The heavier and more gravelly soil phase, however, produced a much more satisfactory crop and the plots which had received no copper were distinctly inferior in appearance and in yield.

At the time of sowing the wheat in 1942, small areas of first early subterranean clover were planted. Where the wheat made good growth on the heavier soil phase, the subterranean clover suffered from competition and made relatively poor growth. On the lighter soil the wheat was poor but the clover was satisfactory except on plots receiving no copper. Analyses of the leaves and petioles of the subterranean clover from these plots are as follows (figures are p.p.m. of copper on the dry basis) :—

Soil Phase.	Fertiliser.			
	Superphosphate.		Superphosphate plus Bluestone.	
	No.	p.p.m. Cu.	No.	p.p.m. Cu.
Whakea Sand—				
Sandy phase	209	2·2	210	7·5
Loamy Sand phase	211	5·1	212	12·4

These analyses indicate acute copper deficiency on the sandy phase and show the effect of the bluestone in raising the copper content. The loamy sand phase would seem to be, at most, mildly deficient in copper judging from the analysis

of the subterranean clover but, as remarked above, showed distinct response in growth of wheat where copper had been used. There is some evidence that the first year growth of subterranean clover is not always a reliable indication of the copper status of the soil. Analyses will be obtained in 1943 to determine the copper content of the subterranean clover, re-establishing itself on these sites.

4.—DISCUSSIONS AND CONCLUSIONS.

The results reported above amplify the information already obtained regarding the value and use of copper-containing fertilisers. Apparently copper is of paramount importance under the conditions of these experiments.

There is some evidence that some other element may also be a factor in short supply and that fertilisers containing it as a supplement in addition to copper may improve the growth of the crop or pasture and possibly the nutritional value for stock. Mixtures including iron, magnesium, manganese, zinc and boron used in these experiments have failed to indicate benefit from extra supplements. However, where roaster residues have been used in a number of instances, the growth and appearance of the oats have been superior to the other treatments supplying a similar amount of copper. For instance, in the 1941 experiment on Mr. Brown's property, on plots fertilised with roaster residues in addition to superphosphate, the oats were taller and the straw more attractive and a brighter golden yellow in colour than elsewhere. However, yields of grain were similar. Owing to the substantial amount of zinc in the roaster residues it was suspected that this element may be exerting a favourable effect on the oats although conclusive yield evidence was not obtained. At the present time there is a certain amount of evidence pointing to a need for zinc on certain Dandaragan and Gingin soils. The zinc content of subterranean clover is low and, at Mungedar, field observations have indicated a greatly superior establishment of subterranean clover where roaster residues have been used in the past. Experiments are being carried out in a number of districts to determine the effect of zinc in addition to copper for the growth of subterranean clover as it seems possible that this species may be more suitable than cereals as an indicator of inadequacy of zinc.

Under the conditions of these experiments the results indicate that oxidised copper ore may be superior to bluestone on copper deficient soils. If this is so, the small additional effect may be due to some undetermined impurities in the crude product. Further investigation is needed on this point. However, these and other results already published do establish the value of the locally mined ore which consists of the surface oxidised portions of copper deposits occurring in many parts of Western Australia.

It may be concluded that on many types of copper deficient soils in Western Australia, a variety of copper-containing fertilisers may be used with equal efficiency. These experiments show that oxidised copper ore and roaster residues, if applied mixed with the superphosphate at rates equivalent to 1¼ to 2½ lbs. of pure copper (5 to 10 lbs. of bluestone) are at least equally as effective as bluestone for the growth of cereals. Copper carbonate pickle, on the other hand, has little or no effect on soils where copper deficiency is acute.

The effect of a single copper dressing lasts for several crops: For instance, the third crop shows no evidence of deterioration even when as little as 5 lbs. of bluestone was used with the first crop, and superphosphate only has been used subsequently. It appears that annual dressings are not necessary for cereals if the first dressing is adequate for optimal results. No exception to this conclusion has yet been observed in experiments in Western Australia, but it must be admitted

that it is possible that some soils may have such a high capacity to absorb the copper that frequent dressings may be necessary. For the maintenance of the copper content of pastures it may be necessary to apply copper-containing fertilisers more frequently than for cereal production. Conclusive evidence in this direction is not yet available but it is hoped that experiments at present in progress will yield the desired evidence at the end of this year.

5.—ACKNOWLEDGMENTS.

Grateful acknowledgment is made of the assistance provided by Mr. J. A. V. Brown and the late Mr. V. G. Rennie in the carrying out of these experiments. These farmers were constant in their interest and at no small inconvenience to themselves arranged for all of the work necessary over a period of years to be carried out efficiently and as required by officers of the Department of Agriculture.

Acknowledgment is also made of the services of the Forestry Department in carrying out statistical treatment of results where possible.

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Cleansing Milking Machines and Care of Rubber-ware.

M. CULLITY, Superintendent of Dairying.

The conquest of Malaya and the Dutch Indies by Japan transferred almost the whole of the natural rubber resources of the world from the control of the United Nations. Great care is being exercised now in all industries where rubber is used in order to reduce the quantity used, and to eliminate waste.

On dairy farms where milking machines are used, the quality of the rubber-ware is of great importance in allowing the production of high quality milk and cream. In the past, farmers have been encouraged to discard their rubber ware and particularly the inflations sooner rather than later, in order to avoid undue contamination of the milk which would result when the rubber begins to perish and absorb butter-fat and other milk substances. Apart from this, it was emphasised that the inflations should not be used if they were stretched or in other ways showing deterioration, as this would cause a direct loss of milking efficiency.

The position now is quite different: rubber is scarce and every farmer is expected to assist in making it last longer. This can be done by being certain

that it is thoroughly cleansed as probably the greatest damage occurs to rubber through the action of grease and dirt. It is fortunate that the methods which will extend its life also allow the production of milk of high quality. The caustic soda and boiling water method has been recommended for many years as a means of keeping milking machines in a sanitary condition as well as tending to safeguard the life of the rubber tubes and inflations.

The details of this procedure are as follows:—

1. Before milking, draw cold water through all milk tubes and the releaser, so as to prevent the adhesion of milk to the pipes, etc.

2. Immediately after milking, wash all dirt off the outside of the teatcups and rubbers, then draw through each set of teatcups sufficient cold (or preferably warm) water to flush out the milk system. When drawing the water through the set farthest from the releaser, insert a ball of horse-hair in the end of the milk pipe to cause it to travel through to the releaser with the water.

3. Next draw through **each set of teatcups not less than one gallon of boiling water** to which caustic soda has been added at the rate of **not less than 1 to 1½ teaspoonsful per 4 gallons of boiling water.** Distribute the solution as evenly as possible through each set of teatcups.

4. Immediately follow by flushing out the caustic soda solution with two gallons of hot water or one gallon of boiling water for each set of teatcups; the flushing with boiling water helps to dry the rubbers and leaves the milk system dry and sweet.

5. Remove or open the plug or flap from the releaser pipe to allow of free circulation of air.

6. **Next clean the vacuum system** in the same manner as the milk system by drawing through first the caustic soda solution, and next the boiling water which has been circulated through the milk system. Pay particular attention to the cleaning of the pipe connecting the releaser to the vacuum tank, by flooding the releaser to cause the water to travel through to the vacuum tank. This is important.

7. The engine can now be stopped. **Disconnect the two long rubbers** from down-pipe and teatcups and hang in a clean airy place out of the sun.

8. Next disconnect the releaser, wash, rinse and place in a clean dry sunny place, then disconnect the top or bottom half of the vacuum tank and treat in a similar manner. **To be successful these operations must be carried out daily.** This does not dispense with the necessity of dismantling the machine as often as possible so that joints and crevices may be examined and treated.

The Technical Officer attached to the Department of Supply has made the following recommendations with a view to preserving, and so extending, the life of rubber-ware:—

"The greatest enemies of rubber likely to be met in milking machine service are:—

1. Copper from brass cups and fittings.
2. Milk fats.
3. Grease, vaseline and ointments.
4. Sunlight.

Copper, particularly in conjunction with fat, grease, etc., will rapidly soften rubber and make it useless. Therefore, where copper or brass fittings are employed, care must be taken to see that the rubber fittings are regularly removed and cleansed.

After considerable use, many of the copper or brass fittings which have been tinned or plated, lose their covering and the copper is then exposed to the rubber-ware. For the complete satisfaction and protection of the user, it is essential that these parts be replated or retinned as early as convenient, so that economical results may be obtained.

Milk Fats.—Milk fat is gradually absorbed by rubber eventually converting it into a soft sticky mass.

Grease, etc.—Grease and vaseline soften and swell rubber and make it more susceptible to the action of milk fat. The user should therefore endeavour to ensure that as far as possible these or similar substances do not come in contact with rubber fittings.

Sunlight.—Sunlight has a harmful effect on all rubber, as it tends to cause perishing or sun-cracking. All milking-machine goods, when not in use, should be kept away from sunlight.

While the deterioration caused by the first three mentioned substances cannot be prevented, it can be considerably delayed by taking care to see that the rubber fittings are regularly removed and cleansed; the cleansing method recommended is as follows:—

1. Completely dismantle the rubbers and metal fittings.
2. Leave overnight in a cold caustic solution of approximately 5 per cent. strength, i.e., ½ lb. caustic soda to one gallon of water.
3. Next day boil for about one hour.
4. Then rinse in cold water.

This method should be carried out at least every one or two weeks, or more often if considered necessary; such cleansing will wash out all foreign matter, and if the rubber fittings are regularly submitted to this treatment, the extra life obtained will far more than compensate for the additional time involved."

Farmers, however, may not find it convenient to adopt the recommendation regarding the boiling of the rubbers in a 5 per cent. caustic soda solution, but they are advised that attention to the thorough removal of all deposits of dirt or grease is essential. The outside of all tubes should be washed regularly after each milking so that the dirt picked up during milking may be immediately removed.

As an alternative to the boiling of the parts in caustic soda, farmers may remove all rubber-ware from the machine once each week and soak for several hours, say between morning and evening milking, in a strong soda solution which is most effective if used hot.

At the Wallaceville Research Institute, New Zealand, it was found that one heaped tablespoonful of metasilicate of soda per gallon of boiling water was most effective. An alternative solution was one containing three parts of soda ash to half part each of metasilicate of soda and trisodium phosphate. The rubbers are immersed in the boiling solution and left to cool slowly. As indicated in the quotation from the Department of Supply circular better results will be obtained if the solution is kept hot for some time.

After prolonged immersion the rubbers can be removed and thoroughly washed before replacing on the machine.

Cape Tulip.

G. R. W. MEADLY.

SUMMARY.

Two species of Cape tulip, *Homeria collina* (Thunb.) Vent. and *H. miniata* Sweet, native to South Africa, are now serious weeds in many parts of Australia. They were introduced originally as garden plants.

Both species are toxic, all parts of the plant being harmful, both when green and dry. A glucoside and an alkaloid have been isolated from different species of *Homeria*.

Stock accustomed to grazing on areas infested with Cape tulip are seldom affected, probably because they avoid the plant. The most serious losses have been experienced among animals brought from a district free of Cape tulip to one in which this weed occurs in quantity.

Chemical sprays have proved unsuccessful and the most effective control measures are grubbing and ploughing. The time for carrying out these operations is governed not so much by the seeding of the weed as the formation of new corms and cormils. This usually commences at the beginning of August.

INTRODUCTION.

Cape tulip is the name applied to *Homeria collina* (Thunb.) Vent. and *H. miniata* Sweet, two species which are widespread in this and other States of Australia. Both are native to South Africa where several other species also occur.

As early as 1859 *H. collina* was catalogued as a garden subject in the Adelaide Botanical Gardens and by 1890 both species were established as weeds in South Australia, Victoria, and Western Australia. Their appearance in New South Wales followed shortly after that date.

Cape tulip provides one of many examples of a plant introduced for ornamental purposes soon becoming a serious weed. It has been declared a noxious weed for the entire State.

Although the extent of infestation in some districts makes eradication impossible, much can be done to control Cape tulip in those areas. Where only small, isolated patches occur, however, complete eradication can be effected. Early recognition followed by prompt action can prevent a few plants from originating a heavy infestation.

DESCRIPTION.

Homeria collina has a single, ribbed, grass-like leaf 12 inches or more long arising from a corm (the so-called bulb) which is surrounded by brown fibrous material. The stem is shorter than the leaf and produces a few flowers which are, at first, enveloped by green spathes. Each flower has six equal segments which are usually predominantly pink with a green or yellow base, but are sometimes entirely yellow. The flowers often exceed an inch in diameter. The narrow cylindrical seed vessel opens at the top to liberate numerous brown seeds. The name one-leaved Cape tulip is often applied to *H. collina*.

Homeria miniata has two or sometimes more grass-like leaves and in consequence is often referred to as two-leaved Cape tulip. These arise from a corm around which are formed numerous cormils (small "bulbs"), the whole being surrounded by dark fibrous material. The flowering stem gives rise to a number of flowers which emerge from green spathes. Each flower has six equal segments,

pink in colour with the exception of the yellow base which is often blotched with green. The diameter of the flower seldom exceeds one inch. During the later stages of growth groups of cormils are formed in the angles formed by the leaves and the stem. The seed vessel and seeds are similar to those of *H. collina*.

A. Homeria miniata. Two-leaved Cape Tulip.

B. & C. Homeria collina (C. seed vessel). One-leaved Cape Tulip.

[Drawing by C. A. Gardner.]

DISTRIBUTION.

There are several extensive areas in Western Australia, the main being the Toodyay-Northam-York-Beverley Districts and the area including Osborne Park, Maylands, Cannington, Bayswater and Bassendean. The extent of the weed in these localities indicate that they were sites of early infestations.

Other areas of varying size and density are distributed from Mingenew to Manjimup and as far east as Kulin and Merredin.

TOXIC PROPERTIES.

Cape tulip is not only significant as a weed but as a poisonous plant. Mackenzie (1910) found that the corm of *H. miniata* contains a glucoside, which has a digitalis-like action on the heart, raises the blood pressure, constricts blood vessels, and has an action similar to curare on voluntary muscle. He states that this glucoside is probably the active principle. Rindl (1924) isolated an alkaloid, homeridine, from the dried stems, leaves and flowers of *H. pallida* Baker and states that Dixon found that this alkaloid had pharmacological actions of the circulation similar to those of digitalis.

There is evidence to show that the poison occurs in all parts of the plants irrespective of whether they are fresh or dry.

Pappe (1857) describes a case of poisoning among natives due to eating the bulbs of *H. collina* and there are many references to losses of animals. Deaths are reported most frequently among cattle, although horses and sheep are also affected. A dose of 2 lb. of green leaves caused fatal haemorrhagic gastro-enteritis in a calf in an experiment carried out by Hindmarsh in June, 1929 (Hurst 1942), while Steyn (1934) found that 220 gm. of the fresh bulbs and leaves in the flowering stage caused the death of a full grown sheep about thirty hours after administration. Similar properties can be assumed for *H. miniata*. Filmer (1926) fed two pounds of chopped leaves of this species to a cow which was found dead the next day.

Stock accustomed to grazing on areas infested with Cape tulip are seldom affected, probably because they avoid eating the plant. Even under these circumstances, however, deaths occur from time to time. The most serious mortalities have been experienced among animals brought from a district free of Cape tulip to one in which this weed is present in quantity. On many occasions deaths have occurred within a few hours.

Although, as mentioned previously, in a controlled experiment, Steyn in South Africa killed a sheep with approximately one half pound of the plant, there is no indubitable record of sheep having been poisoned in this State by Cape tulip.

Clarke (1939) describes the symptoms as partly those of an acute gastro-intestinal irritant and partly those of a cerebral depressant or narcotic. Examples of the first are abdominal pain, diarrhoea, and, if large amounts of green leafy material have been ingested, distension of the stomach with gas, the symptoms increasing in severity and resulting in colic, frequent scouring, great weakness and prostration. The nervous symptoms are indicated by dullness and depression.

Deaths may occur rapidly, within twelve hours or less after ingestion, or the animals may linger for several days.

Carne, Gardner, and Bennetts (1926) describe lesions of intense gastro-enteritis and cardiac haemorrhages revealed by a post mortem examination of a bull poisoned by Cape tulip.

POSSIBLE USES.

The leaves of Cape tulip contain a fibre which is considered by manufacturers to be suitable for reinforcing plaster board. Supplies of sisal fibre for this purpose have been disorganised by the war and Cape tulip has proved one of the most successful substitutes. Gathering and retting for this purpose are still in the experimental stages.

PROPAGATION.

Besides producing a large number of seeds, Cape tulip propagates itself vegetatively, the details varying with the species. *H. collina* normally produces two corms of unequal size above the old withering corm, while *H. miniata* may give rise to several corms along with a considerable number of smaller structures known as cormils. Again, in *H. miniata* similar clusters of cormils are formed in the angles between the leaf bases and the flowering stem.

There is no doubt that, particularly in the earlier days of its introduction, much of the spread of Cape tulip was due to its ornamental nature. Home gardeners, with every good intention, gave corms to friends, but this plant seldom remained confined to the garden boundaries and soon became abundant in localities suited to its growth. Even in recent years Cape tulip has been spread by this means.

Other agencies which have played their part in its dissemination include stock and vehicles, machinery, agricultural seeds, packing and nursery products such as balled fruit trees.

There is little risk of Cape tulip seeds occurring as impurities in graded agricultural seeds, but on several occasions both seeds and cormils have been found in subterranean clover burr and threshed, ungraded seed. Apart from any other consideration this provides ample reason for purchasing cleaned seed.

Straw packing represents a potential source of any weed and Cape tulip corms and cormils have been found in soil forming the balls around fruit trees being distributed from a nursery.

CONTROL.

Any control measures carried out against Cape tulip must be designed, not only to prevent seed formation but also to forestall the development of new corms and cormils. Observations carried out by the author in 1930 and subsequent years have shown that the development of new corms commences about the beginning of August. Cashmore (1938) using pot-cultures found that the first evidence of new corm production occurred during August and early in September.

As, normally, full flowering does not occur until mid-September and seeds are not mature until a month or more later, the time of corm, rather than seed formation influences the initiation of control measures.

A successful chemical spray would be a very convenient control measure but unfortunately, various chemicals have been tried in this and other States with little success. Experiments conducted by this Department proved sodium chlorate, atlacide and sulphuric acid to be ineffective, and Davies (1942) reported that the Council for Scientific and Industrial Research after six years of tests with various chemicals failed to secure satisfactory results with Cape tulip along with a number of other perennial weeds.

The only satisfactory means of control are grubbing and cultivation, the latter often being associated with a cropping programme. Where the areas are small or the plants scattered, grubbing is possible, but where appreciable areas are heavily affected, ploughing is more practical. Unless the plants are grubbed at the beginning of August or earlier there is every chance that new-season corms or cormils will have been formed and remain in the soil when the plant proper is removed. When the flowering stage is reached the basal corm development is well advanced and grubbing at this stage often serves to distribute the weed rather than reduce the infestation, unless extreme care is taken to remove the entire plant. All plants grubbed should be destroyed by burning.

The same principle must be applied to ploughing which should be carried out in late July or early August. A further spring cultivation may be advisable, depending on the regrowth of the tulip, and a summer working, designed to expose as many of the corms as possible, has improved results.

In districts where stock are accustomed to the plant and seldom affected by it, good results have been secured, at the same time deriving some return from the land, by sowing an early maturing crop of oats, grazing heavily until the beginning of August and then ploughing. This practice is more suited to the Great Southern than the lower South-West.

Repeated mowing to prevent flowering will arrest the spread of Cape tulip, although no experimental evidence is available to show whether the density of the infestation is reduced by the operation. Chipping with a hoe will also prevent seed formation but is essentially a measure of control rather than of eradication.

Thoroughness and persistence is required for the control of all perennial weeds and Cape tulip is no exception. A few plants allowed to seed will nullify much good work, and repeated inspections to detect further plants represent an important part of any programme directed against this weed. Spectacular results cannot be expected, and any scheme necessitates carrying out systematic measures for a number of years.

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The Rotting of Superphosphate Bags.

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1. INTRODUCTION.

Farmers in Western Australia are aware that superphosphate left in contact with the bags for long periods causes severe rotting of the fabric. Not only is the fabric rotted but discolouration occurs and the jute changes from grey to brownish or reddish. With the high grade Nauru and Ocean Island rocks used prior to the loss of these islands occasioned by the war, the superphosphate was mild in its action and if proper care were taken the bags generally could be used subsequently for other purposes if they were washed and dried immediately after emptying. Occasionally, however, the bags suffered severe damage. This usually occurred in trucks delayed in transit during periods of hot weather.

The high quality of the pre-war grades of superphosphate and the comparative freedom from complaints, rendered close investigation of the factors causing the deterioration a matter of little moment. It was generally thought that the damage was due largely to fluorine or hydrofluoric acid, but evidence was scanty. Very fine grinding of the rock preparatory to acid treatment in the factory appeared to reduce the damage and some protection was afforded by dusting the bags with alkaline materials or soaking them in mildly alkaline solutions. A wide range of tests have been carried out over a period of years in the factories using dusts, dips, and sprays. The dusts included powdered limestone, lime, soda ash, finely ground rock phosphate, di-calcium phosphate, plaster of Paris, and gypsum. Solutions of sodium acetate, soda ash, milk of lime, gypsum, superphosphate, plaster of Paris, "Rot Proof," blackboy gum, sugar, bluestone-soda ash mixture, copper naphthalate and sodium silicate, have been used as dips. As a spray, soda ash solution has been tried. It has not been necessary to adopt any of these treatments in practice for superphosphate made from Nauru and Ocean Island rock, so that the practical aspects have not been worked out. However, it is recognised that dips are unsuitable on account of the labour involved in the dipping and drying processes. Sprays and dusts may be used with little expense and could easily be adopted as routine practice if effective. The farmer can preserve his superphosphate bags by washing them immediately after emptying to remove harmful ingredients and by drying them thoroughly before stacking for future use.

During 1941-42, supplies from Nauru Island and Ocean Island were cut off and, to supplement the reserves, rock had to be imported from Egypt. In Egypt, the phosphate rock is mined at a depth of about 1,000 feet, where it occurs as a layer below ground water level. It is likely that the water would be at least slightly brackish and the dried rock would contain a little salt. One sample of Egyptian rock analysed recently contained 0.36 per cent. water soluble chloride. This would correspond to 0.59 per cent. salt as NaCl.‡ This rock is of low grade compared with Nauru and Ocean Island material.

The superphosphate marketed in 1941-42 consisted of a mixture of one part from Egyptian rock and three parts from Island rock. Unexpected difficulties arose. Many cases of very severe damage to bags and to the railway tarpaulins

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‡Analysis by courtesy of Mr. Walker of Cresco Fertilisers, Ltd. Since this paper went to press another shipment of rock has been received. This rock contained 0.39 per cent. water soluble chloride which is equivalent to 0.64 per cent. salt.

covering the consignments occurred during the hot weather of December, 1941, and January, 1942. Complaints were so general that investigations were undertaken to ascertain the cause of the enhanced damage and means of control.

2.—INVESTIGATIONS.

It is well known that bags suffering damage from contact with superphosphate are discoloured brownish or reddish and the fibres become brittle and very much reduced in tensile strength. Factors associated with these changes were subject to considerable investigation. Details of the results will be published in the Journal of the Royal Society which will appear at a later date. This paper constitutes a summary of the results of these investigations.

On the assumption that the excessive damage was due to the increased amount of free acid in the new superphosphate mixture occasioned by the need for extra acid to bring about the guaranteed percentage of water soluble phosphate, the manufacturers early adopted as a control the incorporation of a few per cent. of ground limestone with the superphosphate immediately prior to bagging. This proved quite satisfactory in general and has now become standard practice in all factories. In order to affort added protection to the upper parts of the bags which would be likely to come in contact with the tarpaulin, and where damage has been most apparent, soda ash spray is applied to absorb any acid vapors which may be liberated owing to heating during transport.

The laboratory investigations showed that the superphosphate made from Egyptian rock and which was responsible for the excessive damage, contained a small amount of free hydrochloric acid (spirits of salts). On the other hand, superphosphate made from Nauru and Ocean Island rocks contained practically no hydrochloric acid but liberated a small amount of hydrofluoric acid on warming. Subsequent tests with jute twine showed that hydrochloric acid and hydrofluoric acid in dilute solutions were very damaging to fabric. Even the air above such solutions of these acids caused rapid rotting of the twine. Furthermore, it was observed that the hydrochloric acid at similar concentration was very much more severe than the hydrofluoric acid.

The effect of the superphosphates on the jute fabric proved very similar to that of the pure acids in dilute solution. The severity proved to be closely dependent upon the temperature. The higher the temperature the greater the damage. Experiments showed that the superphosphates containing hydrochloric acid were more damaging at lower temperatures than those which contained no hydrochloric acid but which gave off hydrofluoric acid on warming. The addition of salt (sodium chloride) to the Nauru rock prior to acid treatment in the manufacture of superphosphate rendered the action similar to that of the superphosphate from Egyptian rock. The acid used in making the superphosphate would convert part of the salt into hydrochloric acid. Apparently production of hydrochloric acid occurs in the manufacture of superphosphate from rock containing chlorides (either as salt or other active combination), because the ground rock itself had no effect at all on the jute fabric.

The damage to the jute in contact with the superphosphate made from Egyptian rock was very slight at room temperatures which ranged from 65-80°F. At 110°F—which approximates high summer shade temperatures in the wheatbelt—the fabric was severely damaged and the degree of damage increased as the temperature was raised. After three days and four nights at a constant temperature of 160°F., the fabric was reduced to a condition in which it powdered when being rubbed in the fingers. A temperature of 160°F. is well within the range to which the black bodies will rise rise when exposed to the sun during hot summer

weather. It is readily seen, therefore, that bags in contact with railway tarpaulins under the heat of the summer sun would reach temperatures which would bring about rotting of the bags very rapidly and result in severe damage to the tarpaulins. Severe damage from the Nauru Island superphosphate was not observed until 120°F. was exceeded.

Jute twine suspended in the air above the Egyptian superphosphate also suffered damage of a similar type but the action was less severe and higher temperatures were necessary to cause complete rotting. The damage was observed to be severe when the temperature rose above 140°F. The vapor from superphosphate made from the Nauru rock did not appear severely damaging until a temperature of approximately 160°F. was reached.

There seems to be little doubt that the chief agent causing the excessive damage associated with superphosphate made from Egyptian rock is hydrochloric acid. Hydrochloric acid is highly volatile and the vapor would concentrate in the space above the superphosphate as the temperature rose. Sulphuric acid and free phosphoric acid, which occur in small quantities in all superphosphates, are not volatile except at very high temperatures, and tests with the pure acids in solutions show that they have little or no effect in the vapor phase at the temperatures under investigation.

Table 1 shows the effect of increasing temperature in bringing about excessive damage to jute twine in contact with superphosphate and in the vapor phase above it. From this table it will be observed that Egyptian superphosphate is very much more severe than the Nauru superphosphate and that limestone incorporated with the Nauru superphosphate has practically eliminated damage at temperatures as high as 160°F.

TABLE 1.

EFFECT OF TEMPERATURE ON THE LOSS IN STRENGTH OF JUTE TWINE IN CONTACT WITH SUPERPHOSPHATE AND SUSPENDED IN THE AIR ABOVE IT. TIME OF CONTACT: THREE DAYS AND FOUR NIGHTS.

(Figures give the breaking strain of the twine in lb.)
Undamaged Twine averages 36 to 40 lb. breaking strain.

Temperature (°F.).	Nauru Superphosphate.		Nauru super. plus 3% Ground Limestone.		Egyptian. Superphosphate.	
	Contact.	In air above.	Contact.	In air above.	Contact.	In air above.
	lb.	lb.	lb.	lb.	lb.	lb.
about 75	32	41	38	*	39	46
104	27	40	37	*	...	...
113	26	35	37	*	15	37
122	18	40	36	*	12	43
131	12	36	34	*	...	...
140	7	33	30	*	1	18
149	9	35	38	*	...	...
158	4	14	36	*	1	9
167	3	8	34	*	...	...
Water soluble chloride as % hydrochloric acid (HCl) in the super..	*Nil*		*Nil*		0·16	

* No damage observed.

3. CONTROL MEASURES.

It has been ascertained that mixing small amounts of finely ground limestone with the superphosphate greatly reduced the damage to jute fabric in contact with it at moderate temperatures. With the superphosphate made from Nauru and Ocean Island rock the protection is good at temperatures as high as 160°F. With the superphosphate made from Egyptian types, however, the incorporation of ground limestone may fail to be effective if the temperature exceeds 140°F. At 160°F.—which temperature may occur at the point of contact between a black railway tarpaulin and the bag on a hot summer's day—the protection may be very small. The damage resulting from over-heating of the top surfaces of the uppermost bags in a truck may be reduced, however, by spraying with soda ash solution, which would absorb acid vapors liberated at increasing temperatures, and by the use of dunnage or other means of keeping tarpaulins from actually touching the superphosphate. Any means which would effect improved ventilation and the removal of the active vapors would be beneficial.

Considerable care must be exercised in the use of ground limestone. If too little is used the protection of the bags will be inadequate; if too much is used the superphosphate will be liable to set hard in the bags. The acids acting on the excess limestone form a mild cement which may cause considerable inconvenience to farmers wishing to use the superphosphate. In the 1942-43 season, a certain amount of trouble was experienced due to both causes.

It appears that the amount of limestone to be added must be carefully adjusted. The lower limit to avoid damage to the bag appears to be about three per cent., and the upper limit above which setting may be serious is approximately five per cent. As a result of this experience, manufacturers are taking every care to ensure correct mixing and it is hoped that, in spite of manufacturing difficulties involved in the use of the inferior Egyptian rock, improved practice will virtually eliminate future excessive damage to bags or the setting of the superphosphate.

Summarised, the measures necessary to reduce damage to superphosphate bags to a minimum include:—

1. Every care should be taken to avoid over-heating of the superphosphate in the bags due to exposure to the sun in hot weather.

2 A small amount of a suitable alkaline substance such as finely ground limestone, should be incorporated with the superphosphate immediately prior to bagging.

3. the surfaces of the topmost bags of superphosphate in the railway trucks should be sprayed with an alkaline solution, such as soda ash, to protect both the bags and the tarpaulins.

4 Delays in transit between the factory and the farm should be avoided as far as possible, particularly in the hot weather.

5. On the farm the superphosphate should be stacked under cover in as cool a place as possible where ventilation is good. Direct exposure to the sun should be strictly avoided and in no case should the stack be adjacent to an iron wall liable to excessive heat by the sun.

6. If the foregoing precautions are observed there should be no undue damage to the superphosphate bags under normal storage. Immediately after emptying, the bags should be washed and dried prior to stacking for future use.

These measures are being generally applied at the present time.

Plant Diseases in the Home Garden.

W. P. CASS SMITH, Plant Pathologist.

BLACK SPOT AND STEM ROT OF PEAS.

This is a very common and serious disease of peas in all parts of the State during the wet winter months. At least three fungal organisms, namely, *Mycosphaerella* sp. and *Ascochyta* spp. may be responsible for symptoms of this general type, but as their life histories are very similar, they are treated here as one.

The main symptoms will be familiar to anyone who has tried to grow peas during winter; the disease becomes obvious by the occurrence of a conspicuous black or purplish streaking of the lower stem portions, together with a very obvious spotting of the leaves and pods. When the disease is severe the basal stem portions may be completely rotted, causing the death of all above ground parts. In this case the black or purplish discolouration completely encircles the stem, and the lesion may extend several inches above ground level. (Plate 1.) On the leaves the spots may take the form of small brown or purplish irregular dots, or they may be large, more or less circular, and concentrically ringed. (Plate 2.)

Plate 1.
Stem rot of Peas. Note blackening of lower stem. and withering of foliage from the base upwards.

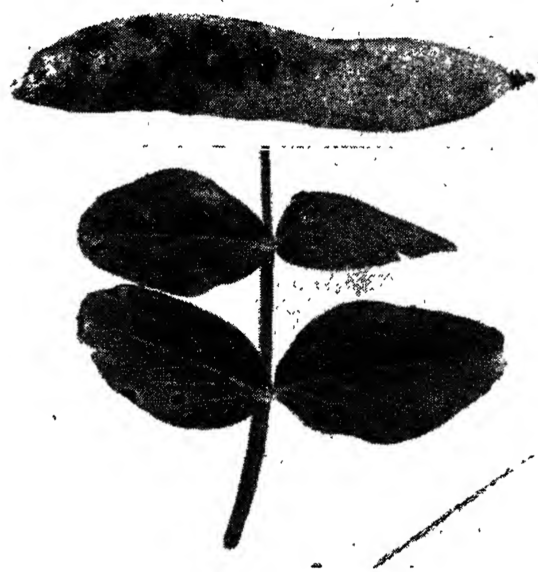

Plate 2.
Black spot of peas showing leaf and pod spot stages.

The disease is seed borne, and its appearance in a garden in the first instance can usually be traced to the use of infected seed. Most commercial samples contain a proportion of black spot infected seeds, and these are often badly shrivelled and discoloured with black, brown or purplish blotches. Culling out discoloured and shrivelled seed from the sample will considerably reduce the disease, but as a few infected seeds may be symptomless the disease cannot be eliminated entirely by this means. (Plate 3.)

However, growers can, if they wish, obtain clean seed by planting a special late spring or summer crop for seed purposes, as the black spot disease is only serious on crops grown during wet weather. When saving seed, any pods or seeds showing discolouration should be avoided.

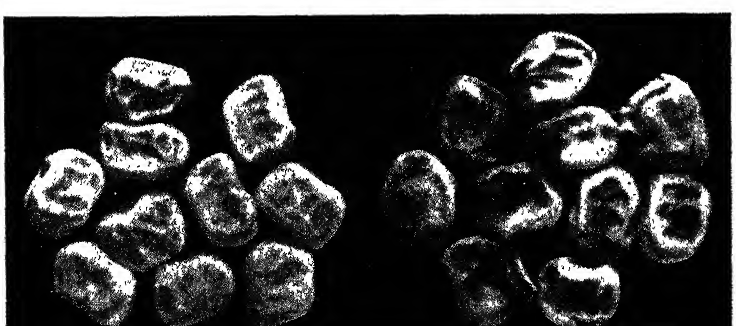

Plate 3.
Good, and inferior quality seed. Black spot and stem rot of peas is often introduced by infected seed; discoloured, cracked, spotted or shrivelled seed, such as that shown on right, should not be planted.

The sowing of infected seed gives rise to diseased plants, and the latter establish infection centres from which the disease is transmitted to healthy plants adjacent by rain splashed spores. Black spot can also persist from one year to the next in diseased crop remains.

CONTROL.

(1) If possible sow only disease free seed harvested from a late spring or summer crop, or if this is unobtainable, carefully handpick and discard all badly shrivelled, discoloured, or cracked seed.

(2) Plant out on land which has not grown peas for two or three years, choosing a sunny, well drained, situation for winter crops.

(3) Inspect plants shortly after emergence and destroy any weakly or spotted specimens.

(4) Support the crop well off the ground with stakes, strings, etc., so that it will dry more quickly after rain.

(5) Immediately the disease is noticed spray with copper containing sprays, covering the stem bases thoroughly, as well as the leaves. Repeated sprayings may be necessary to control the disease during the wet winter weather. Cuprox applied at the rate of 1 oz. in 2 galls. of water is very convenient and suitable for small plantings. For larger areas, Bordeaux mixture, 4 : 4 : 40 strength is recommended. (See Leaflet 536.)

MOSAIC OF PEAS AND BROAD BEANS.

Mosaic of peas and broad beans is caused by a virus which is naturally transmitted by species of aphis.

It is probably transmitted to a limited extent by the seed, and primary crop infection may be due to this cause.

Plate 4.
Pea Mosaic.

On peas, foliage affected with mosaic shows a characteristic mottling of light or yellowish-green and dark green areas, and frequently the mottled areas follow the small veinlets, giving affected leaves a netted appearance. (Plate 4.)

On broad beans the foliage is also mottled and affected leaves are puckered and distorted, and compared with normal leaflets, usually smaller in size. (Plate 5.)

Plate 5.
Mosaic disease on broad bean leaf (right). Healthy leaf on left.

Plants showing the disease at an early stage are stunted, but when late infection occurs stunting is not so obvious.

CONTROL.

1. Plants showing symptoms of the disease shortly after emergence should be rogued out as soon as possible.
2. Keep sap-sucking insects in check by the use when necessary of contact insecticides such as nicotine sulphate.
3. Separate plantings of peas from broad beans and if sowing seed select healthy plants only.

CHOCOLATE SPOT OF BROAD BEANS.

Chocolate spot of broad beans and tick beans occurs yearly during late winter and spring, and its severity depends largely on weather conditions. With continuous rainy weather serious epidemics occur, whereas with dryer conditions it is not so evident.

As the name implies, the disease becomes evident by the occurrence of chocolate coloured spots on the leaves which vary in size from tiny specks up to spots ¼ inch or more in diameter. Brownish streaks also occur on stems and leaf stalks. During wet weather the lesions become so numerous that they coalesce, causing a blighting of foliage, blackening of stems, and in severe attacks, death of whole

plants. (Plates 6 and 7.) Chocolate spot as it occurs locally is caused generally by a fungus (*Botrytis cinerea* Pers.), though a similar spotting of the foliage may sometimes be brought about by sucking insects.

Plate 7.
Chocolate spot of broad beans showing defoliation, stem blackening, and dieback, in final stage.

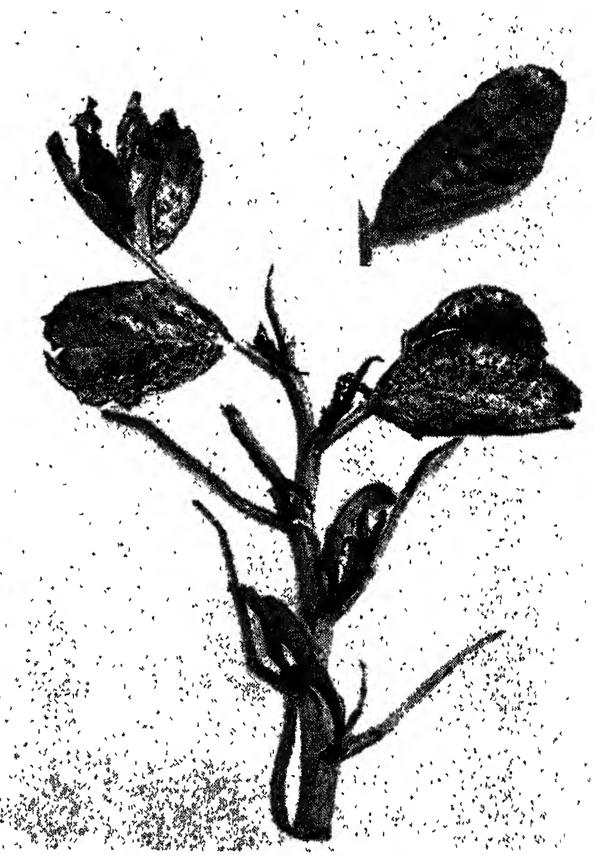

Plate 6.
Chocolate spot of broad beans showing initial leaf spot stage (inset) and blighting of foliage in later stage.

Other fungi, namely, *Cercospora fabae*, and *Ascochyta fabae*, are also responsible for leaf spotting damage, and the last named fungus has frequently been noticed causing a stem and pod spot. When pods are affected with *Ascochyta fabae* the organism often penetrates into the developing seed immediately below the lesion. (Plate 8.)

CONTROL.

(1) Obtain best quality seed and cull out any blemished, discoloured, or shrivelled seeds.

(2) After emergence rogue out any abnormal looking plants.

(3) Plant on well drained soil types as the disease is much more severe on waterlogged soils.

(4) When the disease appears, frequent spraying with copper fungicides as recommended for black spot and stem rot of peas will give good control.

(5) Plantings maturing in late spring usually escape the disease.

Plate 8.
Stem and pod spot of broad beans caused by *Ascochyta Fabæ.*

POTASH DEFICIENCY.*

Prior to the war, troubles due to potash deficiency were relatively rare in this State. Cases investigated by officers of the Plant Pathology Branch were found to be due mainly to unbalanced nutrition caused by an excessively high nitrogen to potash ratio in the applied fertiliser.

They occurred more commonly on light than heavy soil types and were noted in crops of lucerne, cabbage, cauliflowers, and potatoes. On lucerne, suppressed growth or dieback of shoots, after cutting, resulted, while on potatoes and plants of the cabbage family the symptoms were of the type usually referred to by growers as leaf scorch or "rust."

Since the war, however, diseases of this kind have inevitably increased owing to the shortage of potash fertilisers, and believing they were due to parasitic causes growers have in a number of instances applied fungicidal sprays.

To prevent such waste of labour and materials a knowledge of the symptoms is required, especially those shown by plants of the cabbage family and potatoes, which appear to be most subject to this deficiency trouble.

*Written in conjunction with G. H. Burvill, Assistant Plant Nutrition Officer, and L. T. Jones, Agricultural Adviser.

Affected potato foliage is usually ruffled or quilted in appearance, due to a ridging of the tissues between the veins. Later the interveinal tissue takes on a yellowish hue and gradually turns rusty or bronze in colour. Finally numerous dead spots appear in affected leaves which become brittle and rolled upwards. Potatoes appear to be most subject to this trouble during the winter months, and the yield of an affected crop is greatly reduced.

An opportunity was afforded recently to observe the effects of a potash deficiency on cabbages in a controlled experiment at Balcatta. The symptoms in this case were first noticed six weeks after planting, and were as follows:—

> A yellowing was first observed on the tips of the leaves (marginal yellowing) and this extended backwards from the tips or margins, between the veins. Later a "scorch" of the affected areas developed, commencing around the margins, and the dead tissue was brown and brittle. The potash deficient cabbages developed a crinkling of the leaf and were pale green in colour, while those supplied with potash were a deep bluish-green and smooth. (See Plates 9 and 10.)

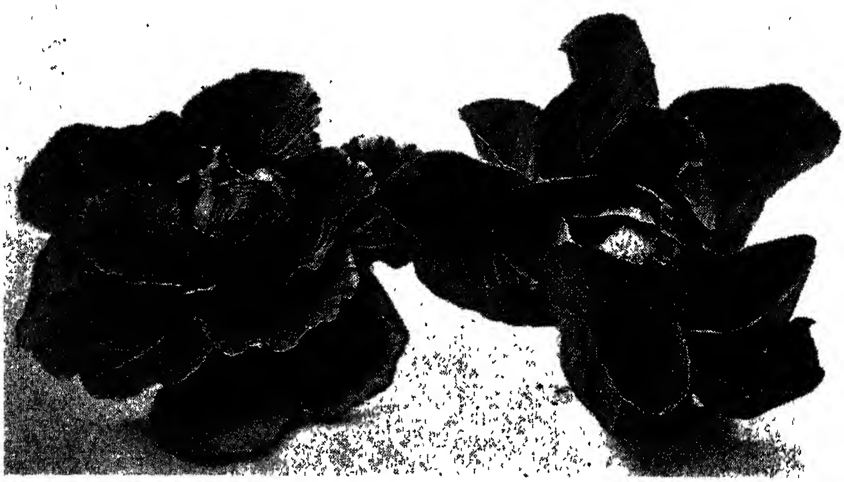

Plate 9.

Left: Cabbage showing potash deficiency symptoms. Note marginal scorch, yellowing, crinkling, lighter green colour, and smaller size compared with cabbage on right.

Right: Cabbage from same area but supplied with sulphate of potash, 2 cwts. per acre. Note good colour, smooth leaf, and better size.

A side dressing of nitrate of soda two weeks before cutting increased the severity of the leaf scorch symptoms.

Sulphate of potash at the rate of 2 cwts. per acre increased the yield, in this instance, from 20 tons to 30 tons per acre, and the cabbages from the plots so treated showed none of the symptoms described above.

Unless potash deficiency symptoms develop and are recognised at an early stage the trouble is difficult to remedy. A recurrence of the trouble should be guarded against when the area is next planted. Potash fertilisers (either sulphate or muriate of potash) at the rate of ½ to 1 oz. per square yard (= 150 to 300 lbs.

per acre) should be used if possible, but owing to war conditions they are at present almost unobtainable. It is hoped that supplies will be available before long from the alunite deposits of Lake Campion in this State.

Plate 10.

Leaves from healthy and potash deficient cabbages shown in Plate 9. Left to Right: (1) Leaf from cabbage supplied with potash. (2) Leaf showing a yellowing extending backwards from the tip—no potash. (3) Leaf showing a marginal scorch. Note the brown and brittle dead tissue—no potash.

For the commercial grower the control of potash deficiency troubles is extremely difficult under wartime conditions. Only limited supplies are available of organic waste materials containing appreciable amounts of potash, e.g., scouring works wastes and barley combings, and therefore, until supplies of potash fertilisers become available, the heavier soil types, naturally richer in potash, should if possible be utilised for the crops referred to earlier.

In home gardens, however, with much smaller areas there are much greater possibilities of overcoming or avoiding potash deficiency troubles.

Animal and poultry manures, compost, river algae, water hyacinth, ashes, and green manure crops all contain potash, but in amounts which depend on various factors. The food of animals and birds is a major factor since it is the source of the manurial ingredients in the manure. Further, with animals such as horses, cattle, and sheep, over half the potash excreted is in the urine so that manure from stables and sheds will be much more valuable as a source of potash (and incidentally of nitrogen) than that collected from paddocks. With compost and green manure crops, if the plant materials which are composted or dug in are grown on a soil of low potash supplying power they will likewise be low in potash, but will nevertheless provide a useful supplement when dug into a potash deficient soil. Green manure crops may collect potash throughout several feet of soil and this is concentrated in the surface layer when the crop is dug in.

From analyses made in 1942, it has been calculated that a very heavy crop of New Zealand blue lupins (36 tons per acre green) grown without potash fertiliser on the sandy soil round Perth returned, when dug in, potash equivalent to ½ oz. of sulphate of potash per square yard. However, from alluvial soil at Upper Swan the lupins were four times as rich in potash. Likewise compost made from lawn clippings and garden refuse, used at the rate of one four-gallon petrol tin per square yard contained potash equal to ½ oz. of sulphate of potash per square yard.

Ashes are a useful source of potash, but the amount they contain varies with the species of tree or plant burned to produce them and also according to the soil on which these grew.

Even on poor sandy soils potash deficiency should not occur if ashes, organic manures and wastes are conserved and dug in at intervals to the garden beds.

Additions of fertile loam to poor sandy soils will help to remove possibilities of potash deficiency, but the chances of introducing weeds and pests such as Guildford grass and eelworm should not, however, be forgotten.

Gardeners interested in green manuring, or the preparation of compost, should refer to leaflets Nos. 679A, 705, and 671, which are obtainable free of charge from the Department of Agriculture.

FAILURE OF PEAS DUE TO LACK OF INOCULATION.

The peas in the top row, which were innoculated with a nitrogen-fixing bacterial culture before planting, made normal healthy growth. Those in the bottom row were not inoculated and did not grow more than a few inches high. Both rows were planted on the same day on soil which had not grown peas before.

For the healthy growth of peas and other plants of the same family (leguminous plants), it is necessary that the correct strain of these root-nodule forming bacteria is present in the soil. Many garden soils already contain these bacteria so that peas may grow well without artificial seed innoculation. Others, however, do not, and peas grown on such soil, after growing only a few inches, usually turn yellow and die. Gardeners who suspect that failure is due to lack of innoculation should test the effect of bacterial cultures which may be obtained from the Department of Agriculture, Perth.

Pig Raising in the Metropolitan Area.

M. CULLITY, Superintendent of Dairying.

Following the outbreak of swine fever in the metropolitan area in October of last year, several thousand pigs were slaughtered with the result that approximately 100 piggeries went out of production. Further, owing to the ban on the use of camp refuse and city garbage, the main source of a cheap foodstuff for the remainder was eliminated. Some concern therefore has been expressed at the future of the industry in the metropolitan area, particularly as it relates to the feeding of store pigs reaching the livestock markets from country areas.

However, bacon pigs of excellent quality can be produced by feeding a mixture of grain with a supplement of meat-meal. The quantity of grain and meat-meal required will depend on whether there are other substances available—such as pasture and root crops, which would reduce the quantity of grain which it is necessary to purchase, or protein-rich foods such as skim-milk, young green lucerne, pasture, peas, etc., which would lower the amount of meat-meal required. It is in most cases profitable, where the land is available, to grow crops which will in this way reduce the need for purchased food.

The following table indicates the value of a number of substances which may be available, expressed as the amount of each which would be equivalent to 1 lb. of grain.

Weights of various foods equivalent to one pound of grain.

8-12 lbs.—Cabbage, cauliflower, melons (15 lb.), pumpkin, kale, kohl rabi, mangols, carrots (7-8 lb.), turnips, apples.

4-6 lbs.—Potatoes, sweet potatoes.

The results of Pig Feeding Trials at Muresk Agricultural College indicate that 10 bushels of wheat are used for each bacon pig reared (inclusive of the grain used for sows and boars). This figure is confirmed by results obtained by Mr. Giles of Doodlakine, reported elsewhere in this Journal.

It is recommended that 10 per cent. of meat-meal be used in the ration—i.e., that 1 lb. of meat-meal be mixed with every 9 lb. of grain. Bone-meal or ground limestone equal to one part in 50 of the mixture should also be used.

From these figures the farmer may calculate the approximate cost of feed for each bacon pig marketed—e.g.:—

	£	s.	d.
10 bushels of wheat @ say 4s. per bushel	2	0	0
66 lb. meat-meal @ say 1½d. per lb.	0	8	3
13 lb. bone-meal @ say 1½d. per lb.	0	1	8
	£2	9	11

This feeding should produce a pig which would be about 135 lb. dead weight and valued at £4 10s. (135 lb.). We therefore have a margin of £2 per pig to cover the other costs entailed in producing—such as the interest on the land and buildings, depreciation of buildings and stock and marketing costs. It is unlikely that these costs would absorb 20s. so that 20s. would be left to cover the cost of labour and profit.

In this way it can be seen that one man marketing 250 pigs would gain a little better than the basic wage: with an output of only 12 pigs per sow per annum, he would require only 20 sows. This is well within the capacity of one man. It has been demonstrated that where facilities are suitable one man can manage 50 sows and their progeny. These sows producing only 12 pigs per year would enable him to market 600 baconers and allow him a substantial income.

In the foregoing calculation a value of 4s. per bushel was adopted. Wheat of f.a.q. quality can be purchased from the Wheat Board at 3s. 3½d. in bulk. Frequently inferior quality wheat, bin damaged, is available at prices much lower.

It is suggested, therefore that it is possible for pig raisers in the metropolitan area to continue their activities even if they have to feed wholly on purchased food.

The following points should be considered by farmers desiring to stabilise their activities under the altered conditions.

1. Select breeding stock of good type and of high prolificacy.
2. Grow as many fodder and root crops as possible to reduce the need for purchased food.
3. Buy wheat at the lowest possible price.
4. Use a protein supplement such as meat-meal in adequate proportion.
5. Use a mineral supplement.
6. Make the piggery convenient so as to enable as many pigs as possible to be handled by one man.

Experiments on the Effect of Adding Ground Limestone and Slaked Lime to the Superphosphate Used for Wheat Growing.

G. H. BURVILL, Assistant Plant Nutrition Officer, and H. G. CARISS, Agricultural Adviser.

SUMMARY.

Experiments were carried out in 1942 at Chapman, Merredin, and Wongan Hills Research Stations with a range of superphosphate-ground limestone mixtures as fertiliser for wheat. Increased amounts of the mixtures were applied to give each plot the same dressing of super. The crops were planted two to four weeks after the mixtures were made up.

The addition of up to 20 per cent. of ground limestone to the super had no effect on yields. A mixture of super and 20 per cent. slaked lime gave a slightly reduced yield at Wongan Hills, but not at Chapman and Merredin.

INTRODUCTION.

Severe rotting of superphosphate bags and railway tarpaulins occurred in many consignments during December, 1941, and January, 1942. The trouble was associated with the use of phosphate rock from Egypt, which had to be substituted in part for the phosphate rock from Nauru, Ocean and Christmas Islands, which—in normal times—is used for superphosphate manufacture in this State.

Fortunately, it was soon found that the addition of a small percentage of ground limestone to the super before bagging greatly reduced the rotting of the bags and damage to railway tarpaulins.

Studies to determine the fundamental cause of the rotting were made and are outlined in an article by Teakle and Hill (1943) in this issue. In this work it was found that at high temperatures (158°F) some samples of super from Egyptian rock were very damaging to jute string unless considerable amounts—up to 12 per cent.—of pure carbonate of lime were mixed with them.

Since the addition of such amounts of basic material to the super was expected gradually to reduce the water soluble phosphate by reversion to less soluble forms, the possible effect on the manurial value of the super came into question. Accordingly, although planting for the 1942 season had already started, experiments with wheat were arranged at the Research Stations at Chapman, Wongan Hills, and Merredin. The object was to compare various mixtures of super and ground limestone as fertiliser for a wheat crop. It was realised that it would not be possible to keep the experimental mixtures for more than a few weeks after mixing before planting.

THE EXPERIMENTS.

The superphosphate used as a basis for the experiments was a mixture composed of 70 per cent. super from Christmas Island rock and 30 per cent. super from Egyptian rock. This had somewhat more Egyptian rock super than most of the super sold early in 1942. The mixed super was supplied by Cuming Smith & Mt. Lyell Farmers Fertilisers, Limited, and through courtesy of that firm was made up into mixtures with 4, 8, 12, and 20 per cent. of ground limestone, and also with 20 per cent. of slaked lime. The ground limestone contained approximately 60 per cent. of calcium carbonate. The mixtures were made up on 15th May, 1942, and were sown on 25th May, 29th May, and 12th June, at Merredin, Chapman, and Wongan Hills respectively. All three experiments were planted on fallowed land which had received several previous dressings of super over a period of years.

The treatments used and the yields obtained are set out in Table 1. All plots, except the no fertiliser plots, received the same amount of super, i.e., increased amounts of the mixtures were applied to allow for the added limestone and slaked lime.

The yield data indicate that in these three experiments the addition of ground limestone or slaked lime to the superphosphate has had little, if any, real effect.

At Chapman the no fertiliser plots gave yields comparable with those from the other treatments. This has also been noted in other fertiliser experiments at Chapman and has recently been discussed in this Journal by Teakle and Cariss (1943). Apparently the Chapman soil has reached a stage of saturation with phosphate where it is able to supply the needs of a wheat crop on fallow.

At Merredin, where the experiment was on heavy land, all treatments receiving super alone, or in mixtures, yielded close to three bushels per acre more than the no fertiliser plots.

On sandplain country at Wongan Hills, yields were lower than at Merredin, but again the use of superphosphate raised the yields by two to three bushels per acre above the no fertiliser plots. Next to treatment A (no fertiliser) the lowest yield was given by the super-slaked lime mixture of treatment G. The difference in yield between treatment G and treatments C and B is probably a real one, and not due to chance variations among the plots.

TABLE 1.

YIELDS OF WHEAT WHEN FERTILISED WITH VARIOUS MIXTURES OF SUPERPHOSPHATE AND GROUND LIMESTONE AND SLAKED LIME.

Randomised Block Experiment—Five Replications.

Fertiliser Mixtures made up 15th May, 1942.	Chapman.	Merredin.	Wongan Hills.
Date of Planting	29th May	25th May	12th June
Date of Germination	3rd June	5th June	24th June
Wheat Variety	Nabawa	Bencubbin	Merredin
Superphosphate (lbs. per acre) in Treatments B to G	60	60	70
Treatment—	Grain Yields—Bushels per acre.		
A. No fertiliser	11·33	20·05	10·88
B. Superphosphate	10·75	23·03	13·65
C. Super. + 4 % ground limestone	10·35	22·98	13·68
D. Super. + 8 % ground limestone	10·98	23·15	12·80
E. Super. + 12% ground limestone	11·12	23·33	13·02
F. Super. + 20% ground limestone	11·63	23·16	13·37
G. Super. + 20% slaked lime	10·22	22·97	12·53
Smallest difference between treatments which may reasonably be considered not due to chance (P = ·05)	*	·36	·91

* At Chapman, all differences may be ascribed to chance variations between plots other than the fertiliser treatments.

CHEMICAL COMPOSITION OF THE FERTILISER MIXTURES.

When the fertiliser mixtures were prepared samples were bottled and kept at the fertiliser works. On 25th May, i.e., the date on which the experiments at Merredin were planted, these mixtures were analysed in the laboratories of Cuming Smith & Mt. Lyell Farmers Fertilisers, Limited, for water soluble, citrate soluble and acid soluble phosphoric acid. It was thought that this data would give some indication of changes in the mixtures by the time the fertiliser was placed in the ground. It is realised, of course, that reactions causing the reversion of water soluble phosphate to less soluble forms could occur during water extraction in the analysis and not during storage. Especially may this have occurred with the super-slaked lime mixture (see Table 2).

Table 2 shows the analyses of the mixtures calculated on the basis of the superphosphate contained in each.

The analyses indicate that even though reactions during analysis may have occurred, a high proportion of water soluble phosphoric acid was still recorded for all the mixtures containing ground limestone. The decreases which occurred were largely accounted for in the increase in the citrate soluble fraction. In the mixture containing 20 per cent. of slaked lime the analysis shows only 2.58 per cent. water soluble with 17.25 per cent. citrate soluble. Whether this represents a change which had occurred prior to analysis it is impossible to determine.

ACKNOWLEDGMENT.

The willing co-operation of Cuming Smith & Mt. Lyell Farmers Fertilisers, Limited, in making up and analysing the fertiliser mixtures is gratefully acknowledged.

TABLE 2.

ANALYSES OF SUPERPHOSPHATE–GROUND LIMESTONE AND SUPERPHOSPHATE-SLAKED LIME MIXTURES, 10 DAYS AFTER MIXING. CALCULATED FOR COMPARISON ON THE BASIS OF THE SUPERPHOSPHATE IN EACH MIXTURE.

Mixture.	Super-phosphate.	Superphosphate plus—				
		4% Ground Lime-stone.	8% Ground Lime-stone.	12% Ground Lime-stone.	20% Ground Lime-stone.	20% Slaked Lime.
Treatment	B	C	D	E	F	G
Phosphoric Acid (P_2O_5), per 100 parts of Superphoshate in Mixture.						
Water Soluble ...	18·80	18·05	17·83	17·08	15·36	2·58
Citrate Soluble ...	1·45	2·09	2·55	3·43	4·92	17·25
Acid Souble	·95	·96	·92	1·04	1·04	2·07
Total ...	21·20	21·10	21·30	21·55	21·32	21·90

REFERENCES.

Teakle, L. J. H., and Hill, H. E., 1943. The Rotting of Superphosphate Bags. *Jour. Agric., W. Aust.*, 20 (2). (*Second Series*), page 138.

Teakle, L. J. H., and Cariss, H. G., 1943. Superphosphate Requirements for Growing Wheat in Western Australia. *Jour. Agric., W. Aust.*, 20 (1), (*Second Series*), 1-28.

A Note on the Longevity of "Hard" Sub-clover Seed.

A. B. ADAMS.

This experiment, although conducted only on a laboratory scale, indicates that the protective coating of "hard" subterranean clover seeds prevents deterioration of their germinating properties over long periods, even after previous contact with superphosphate.

In 1929, a number of Dwalganup Early subterranean clover seeds were placed in superphosphate for some time and were then tested for germination. They were compared with seeds that had not been in contact with superphosphate.

Those that failed to germinate (from both lots) were assumed to be "hard" seeds, placed on one side for a further test, and forgotten until April, 1942.

On testing them again, 8.7 per cent. of the seeds that had been in superphosphate germinated, and also 11 per cent. of seeds that had not been in contact with the fertiliser, but the balance were quite unchanged.

The seed coats of ten unaltered seeds from each lot were scratched sufficiently to expose a little of the cotyledon and they were again tested for germination. All the seeds so treated germinated.

Hence it can be stated that the "hard" seeds of subterranean clover, in spite of rough treatment in 1929, survived with unimpaired germinating capacity until 1942.

Australian Dairy Produce Board (Pasture Improvement Committee) Species Trials.

H. G. ELLIOTT, Agrostologist.

F. E. RYAN, Field Technician.*

The Australian Dairy Produce Board Pasture Improvement Committee (W.A.) made available sums of money to be used for demonstrating to the farmers in this State means of improving the existing pastures.

The State Committee in co-operation with the Department of Agriculture decided to lay down two Species Trials to demonstrate the value of introduced species of grasses under dry land farming conditions.

Two properties were selected for these trials, one at Forest Grove and the other at Denmark. The trials have been in progress since 1937, and this article gives the information obtained.

A. Millar, Forest Grove.

Introduction.—The pastures in the Forest Grove area consist mainly of pure stands of clover with volunteer annual grasses. They are generally subterranean clover but also drooping flowered clover (*Trifolium cernuum*) and certain minor clovers such as hop clover (*Trifolium procumbens*) and suckling clover (*Trifolium dubium*). The annual grasses are barley grass (*Hordeum marinum*) and brome grasses (*Bromus spp.*). In order to demonstrate the value of introduced grasses in improving the existing pastures, this trial was laid down in 1937.

Object.—The object of the trial was to demonstrate the value of the introduced grasses in improving the existing pastures and to show the need for the choice of suitable strains for these areas.

Materials and Methods.

Layout.—An area of 10 acres was selected on the property of Mr. A. Millar of Forest Grove and divided into five paddocks of two acres each as shown in the following plan.

——————To Forest Grove.

Paddock 5	Paddock 4	Paddock 3	Paddock 2	Paddock 1	
x	x	x	x	x	

Race to Water Supply——————

x Gates.

The soil is red karri loam and was previously timbered with karri and red gum. It was cleared about 12 years before the commencement of the trial and grew subterranean clover for a number of years. It was cropped with maize and this was followed in 1936 with oats and peas. Ploughing was delayed in 1937 to give the weeds time to germinate and the area was plowed with a disc

* Field technician employed by the A.D.P. Board Pasture Improvement Committee (W.A.).

plow, cultivated with a spring-tyne cultivator, harrowed, rolled (using T bar roller) seeded and then cross rolled The sowing took place in May and the area was sown as follows:—

Paddock 1.	Commercial perennial ryegrass	8 lb. per acre.
Paddock 2.	Yorkshire fog	4 lb. per acre.
Paddock 3.	Italian ryegrass	8 lb. per acre.
Paddock 4.	Phalaris tuberosa	4 lb. per acre.
Paddock 5.	Clunes perennial ryegrass	8 lb. per acre.

Germination.—A good germination occurred on all paddocks and heavy rain was experienced during the first two months, twenty-four inches being recorded between April, 14th and June, 29th. A spell of fine weather at the end of June ensured a successful establishment of the sown species.

Reports on Growth.—Observations were made in August, 1937; the commercial perennial ryegrass, Clunes perennial ryegrass and Phalaris tuberosa were making very strong growth. Italian ryegrass was making moderately good growth and Yorkshire fog was somewhat slow in making winter growth. It was noticed, however, that no clover had grown on the areas since the very thorough working and in the autumn of 1938, midseason subterranean clover was sown at the rate of 2 lb. per acre.

In April, 1938, it was evident that the ryegrass and Phalaris tuberosa had successfully withstood the summer drought period and were making very good recovery.

Paddock 5 (Clunes Victorian perennial ryegrass) was very good and only slightly better than the commercial perennial ryegrass on Paddock 1. Phalaris tuberosa was growing very strongly but the plants were more scattered than the ryegrass.

The Yorkshire fog paddock was weakest of all. Light grazing was carried out in January, 1937, and in April, 1938, and observations made in June, 1938, revealed that Paddocks 4 and 5 were recovering well and that Paddocks 1, 2, and 3 were more backward. Paddock 3 with Italian ryegrass appeared to be going back to clover whilst Paddocks 1 and 2 were inferior to Paddocks 4 and 5.

In October, 1938, subterranean clover was growing strongly to become the dominant species in the pasture. The Clunes perennial ryegrass was still growing vigorously on Paddock 5.

1939.—Paddock 4 was improving, having a greater number of plants than during the previous year. Clunes perennial ryegrass and commercial ryegrass were the grasses during the summer months.

Plot 1—Commercial perennial ryegrass.

During 1938 the ryegrass on this paddock made good recovery following the summer drought of 1937-38 and grew strongly. However, it was slightly inferior to the Clunes perennial ryegrass on Paddock 5. By June it was observed that this paddock was somewhat backward and was not making such good winter growth as were Clunes perennial ryegrass or Phalaris tuberosa. By October, the midseason clover which was sown in the autumn of 1938 had become the dominant species in the pasture. Over the summer months this paddock grew strongly and was almost as good for these months as Paddock 5. During 1939 it became evident that the commercial ryegrass was going out and failing to persist and in the autumn of 1940 this paddock was replowed and sown with Clunes perennial ryegrass.

Subsequent growth on this paddock has been disappointing, this being due to lack of grazing management. The lack of efficient grazing management was brought about by the death of the farmer. Subsequently the paddocks were thrown open and a form of continuous grazing adopted in place of the intermittent or rotational grazing previously in use.

Plot 2—Yorkshire Fog.

Following a very good germination, this grass failed to make very much growth during the winter months and in this respect proved inferior to the Clunes ryegrass and to Phalaris tuberosa.

During 1938, following the summer drought of 1937-38, this paddock proved to be weakest of all; the winter growth was slow and inferior to that on Paddocks 4 and 5. By October the midseason sub. clover which had been sown in the autumn of 1938 had become the dominant species in the pasture. During 1939 this paddock was very poor and it was replowed in 1939 and resown to Clunes perennial ryegrass.

This paddock has since proved disappointing for the reason given for Paddock 1, that is, it has failed to persist.

Plot 3—Italian Ryegrass.

Italian ryegrass made moderately good growth during 1937, and an excellent recovery was recorded in 1938. The winter growth was somewhat disappointing and was inferior to Paddocks 4 and 5. The subterranean clover was very good on this paddock by October. A full stand of Italian ryegrass was obtained in 1939 and good growth was obtained throughout the year.

During 1940 growth was again good but the stand was not so thick as previously, and it was evident that the Italian ryegrass was going out. During 1941 only a few plants could be found, and by 1942 this grass had completely disappeared.

Plot 4—Phalaris tuberosa.

After a good germination in 1937, strong growth of Phalaris occurred during the year. Good recovery following the 1937-38 summer drought was obtained, and during 1938 the plants grew very strongly but were somewhat scattered. The winter growth on this paddock was good and compared favourably with Clunes perennial ryegrass—these two paddocks being superior to the other three.

During 1939 the plants of Phalaris thickened up considerably and a good pasture was obtained. During 1940 the Phalaris on this area had thickened to form a reasonably good pasture and during 1941 and 1942, both this paddock and No. 5 were superior to the remaining three paddocks.

Plot 5—Clunes Perennial Ryegrass.

A good germination of this grass occurred in 1937, and growth continued well during the year. Recovery following the summer drought of 1937-38 was very good, and this paddock was the best of the five paddocks although only slightly better than Paddock 1 in the second year. The winter growth during that year was also very good. During the spring months this paddock developed into a good pasture mixture as the result of a good growth of subterranean clover following the seeding in autumn 1938.

By 1939 this paddock had become well established and was without doubt the best paddock of the series.

Over 1940, 1941, and 1942, this paddock continued to provide a good pasture of perennial ryegrass by the subterranean clover present in the sward deteriorated except on a strip which was fertilised with bluestone.

GENERAL.

Subterranean Clover.—When the trial was first laid out, it was expected that a regeneration of subterranean clover would provide the legume for the grass-clover association. This did not prove to be the case and during the first year (1937) very little subterranean clover was present on the paddocks. As a result of this midseason sub. clover was sown in the autumn of 1938 and a comparatively good stand had been obtained by October of that year over all paddocks.

During 1939 the stand of sub. clover declined and was replaced to some extent by minor clovers—hop clover, suckling clover, etc. A strip of bluestone and another of manganese sulphate was applied in the autumn of 1940 across all paddocks to encourage the growth of sub. clover. The bluestone strip produced a reasonable stand of sub. clover in 1941 and had become well established on this strip in 1942. Thus it can be reasonably assumed that the failure of the clover to form a pasture with the introduced species was due to a deficiency of copper in the soil.

Clunes Perennial Ryegrass.

When paddocks 1 and 2 failed to persist, they were ploughed up and resown with Clunes perennial ryegrass. This grass had originally been sown on paddock 5 and proved very successful, but on paddocks 1 and 2 a much poorer stand was obtained. This apparently was due to:—

(1) The comparative lack of fertility due to the failure of the sub. clover to persist on these paddocks; and

(2) Inefficient management of the paddocks during 1940, 1941 and 1942.

In respect to (1), it was noted that a better result was obtained on the bluestone strip than on the remainder of the paddocks because of the increased growth of clover on this section.

In respect to (2) it is necessary to point out that when the paddocks were first laid down, they were given very good management and attention, but following the death of the farmer the system of management was altered and this may have been responsible for the poor establishment.

DENMARK RESEARCH STATION.

In order to test the value of various perennial species and strains of perennial grasses at Denmark a species trial was commenced in 1937.

The trial consisted of five paddocks, each of two acres, which were planted with the following:—

Paddock 1—Phalaris tuberosa	4 lbs. per acre.
Paddock 2—Clunes perennial ryegrass (Vic. certified)	8 lbs. per acre.
Paddock 3—Yorkshire fog	4 lbs. per acre.
Paddock 4—Italian ryegrass, New Zealand	8 lbs. per acre.
Paddock 5—Commercial perennial ryegrass	8 lbs. per acre.

The trial was laid down on Fields 15 and 18 of the Denmark Research Station.

The soil types represented on these paddocks are as follows:—Paddocks 1, 2 and 3 consist mainly of grey sandy loam which extends to the subsoil.

The coarser sand and gravel country comes into the south-western corner of this six acres and covers approximately one acre.

The south-west corner of paddock 5 is stony with small outcrops coming through the surface. The remainder of this paddock is sandy loam of good depth. Paddock 4 has a sandy loam surface but is underlain with gravel at about two inches.

OBJECTS.

1. To determine what species are most suitable for incorporating into the existing sub. clover pastures in the Denmark region.
2. To demonstrate the value of certified strains of seed over commercial seed.
3. To record the periodicity of growth of the various species and their persistence in this district.

MATERIALS AND METHODS.

Cultivation.—The area was ploughed on 2nd May, 1937. It was then harrowed six times and rolled twice. The paddocks were sown on 17/3/37 and the area harrowed following seeding.

Fertiliser.—At the time of sowing, superphosphate and ammonia No. 3 were applied at the rate of 2 cwts. per acre and a spring application of 1 bag of superphosphate per acre was made in September, 1937.

1938	2 cwts. super. per acre applied in Autumn 1 cwt. super. per acre applied in Spring	Total, 3 cwts. per acre.
1939	2 cwts. super. per acre applied in Autumn 1 cwt. super. per acre applied in Spring	Total, 3 cwts. per acre.
1940	2 cwts. super. per acre applied in Autumn 1 cwt. super. per acre applied in Spring	Total, 3 cwts. per acre.
1941	2 cwts. super. per acre applied in Autumn 1 cwt. super. per acre applied in Spring	Total, 3 cwts. per acre.

Plot 1—Phalaris tuberosa.

An excellent germination of Phalaris tuberosa occurred and the plants made vigorous growth during 1937. The recovery of sub. clover following the cultivation was very poor and only a small quantity of this clover was growing in conjunction with the Phalaris during the first year. A fair amount of bracken had grown on the plot and this was mown in September and again in November to control the ferns.

The recovery following the very dry summer period of 1937-38 was very good and in this respect Phalaris proved more drought resistant than the other species sown.

By March, 1939, the Phalaris paddock was becoming fairly well established, was very vigorous and the plants were spreading. By August the establishment of the Phalaris was complete. Sub. clover had thickened up and formed a dense cover, particularly on the western end.

In January, 1940, paddock 1 was cut for hay and the estimated yield from this paddock was 2-2¼ tons. By June, 1940, Phalaris tuberosa was making prolific growth and was grazed down. Growth and production from this have continued and the pasture is still vigorous and productive.

Plot 2—Clunes Perennial Ryegrass.

As with Phalaris an excellent germination of Clunes perennial ryegrass was obtained, but as for Paddock 1 there was practically no clover during 1937. The bracken fern on this paddock was mown in September and again in December to control the fern.

Following the drought of 1937-38 summer period, the Clunes ryegrass recovered fairly satisfactorily, but not so well as Phalaris tuberosa.

By March, 1939, this paddock was becoming fairly well established, but was somewhat patchy. By July the ryegrass was growing very well in conjunction with sub clover which had thickened up to a very dense stand.

In January hay was cut from the paddocks and its estimated weight was 36-38 cwts.

Observations made just before spring revealed that this paddock had become firmly established as an excellent pasture sward.

During 1941 the paddock maintained a good balance of grass and clover and formed an excellent pasture sward. This paddock has given very good results and the suitability of Clunes perennial ryegrass has been clearly demonstrated.

Plot 3—Yorkshire Fog.

A very high percentage germination was obtained and all plants showed vigorous growth to such an extent that practically full ground cover was obtained in the first year. However, there was a complete absence of subterranean clover.

Recovery following 1937-38 summer drought period was not so good as paddock 1, but was reasonably good.

By March, 1939, the Yorkshire fog was well established and flourishing. A strong stand of subterranean clover had developed and a good pasture had resulted.

In January, 1940, an estimated weight of 38-40 cwts. of meadow hay was cut from this paddock.

In the beginning of spring, 1940, this paddock had produced an excellent pasture, which it maintained during 1941, but at the last inspection in 1940, it was beginning to thin out, indicating that this grass was not as persistent in this area under intensive controlled grazing as Phalaris tuberosa or Clunes perennial ryegrass, but has proved a very valuable grass for this district.

Plot 4—Italian Ryegrass.

This paddock showed reasonable germination in the first year, but had a very heavy growth of annual weeds. During the establishment year this paddock was mown to control these annual weeds.

During 1938 very good growth occurred on this paddock and it provided more grazing than either of the other four paddocks.

During 1939 the stand of Italian ryegrass began to thin out and by 1940 this grass had disappeared.

Plot 5—Commercial Perennial Ryegrass.

A reasonable germination was obtained from this paddock in 1937, but it was heavily infested with annual weeds, mainly grasses. This paddock was also mown to control this annual growth.

During 1938 this paddock produced a reasonable amount of pasture and was equal in grazing to paddock 2.

By March, 1939, this grass had practically gone out and in that year the paddock was reploughed.

GENERAL.

Some interesting observations were made over the 6-year period during which the trial was in progress. During 1939 Italian ryegrass which might be expected to get away early was very slow in making growth and in the first report in March, 1939, very little of it could be found, although the perennial grasses were making reasonably good growth. This ability of perennial grasses to produce a good early bite enhances their value as pasture plants, providing that they are not overgrazed at this period.

In 1938, during the first months of the year, a severe drought occurred and it was noted that Phalaris tuberosa was superior to the other species in its recovery.

During the January of 1940 a heavy fall of rain occurred and there was a decided increase in production from the few plants of Paspalum dilatatum which were present in the sward. This is a summer growing grass and the unusual nature of the early rains enabled it to make fairly good growth as opposed to the slower response from the winter growing species in the paddocks.

The invasion of paddocks 4 and 5 with what appears to be a local perennial ryegrass is of interest, and it is probable that by selection good local strains of perennial ryegrass may be obtained from this area.

Botanical Analyses.

Botanical analyses were made in July and August of 1939, in September-October of 1941, and again in September of 1942. They may be summarised as in the attached table.

BOTANICAL COMPOSITION OF PADDOCKS.

Species.	17-7-39.			11-8-39.			September, 1941.			September, 1942.		
	Paddock 1.	Paddock 2.	Paddock 3.	Paddock 1.	Paddock 2.	Paddock 3.	Paddock 1.	Paddock 2.	Paddock 3.	Paddock 1.	Paddock 2.	Paddock 3
Clunes perennial ryegrass	...	15·7	....	...	10·85	...	...	43·0	...	...	50	....
Phalaris tuberosa	6·95	...	...	8·45	....	....	16·0	...	...	28·7	....	....
Yorkshire fog	..	...	26·9	...	...	19·7	....	...	29·0	....	..	20·7
Subterranean clover	81·0	73·5	69·3	83·2	81·80	72·3	58·0	38·0	62·0	65·5	49	75·3
Weeds	4·1	0·9	1·2	2·50	1·15	1·05	8·0	14·0	9·0	....	....	....
Other grasses	3·8	3·0	0·5	4·05	0·3	3·55	16·0	....	....	5·8	1·0	4·0
Bare ground	4·15	6·9	2·1	1·80	5·9	3·40	3·0	5 0	...	....	....	....

The botanical analyses show the increases in the various sown grass species occurring between 1939 and 1942. Thus the percentage composition of Clunes perennial ryegrass increased from 10.85 per cent. in 1939 to 50 per cent. in 1942. Phalaris increased from 8.45 per cent. in 1939 to 28.7 per cent. in 1942, whilst Yorkshire fog increased from 19.7 per cent. in 1939 to 29.0 per cent. in 1941, and then declined to 20.7 per cent. in 1942.

Grazing.

During 1937 all paddocks received about the same amount of light grazing.

During 1938 the Italian ryegrass plot provided most grazing, whilst the Yorkshire fog paddock was slightly better than the remaining three paddocks.

During 1939 Phalaris tuberosa paddock was slightly below the Clunes perennial ryegrass and Yorkshire fog.

During 1940, however, the more drought resistant Phalaris was superior to both Clunes perennial ryegrass and Yorkshire fog.

During 1941 all paddocks provided the same amount of grazing, but it was noted in 1942 that the Yorkshire fog paddock was beginning to thin out and it appeared to be failing to persist.

SUMMARY.

A species trial with Phalaris tuberosa, Clunes perennial ryegrass, Yorkshire fog, Italian ryegrass, and commercial perennial ryegrass was conducted on the Denmark Research Station, Denmark.

Good pastures of Phalaris tuberosa and subterranean clover, Clunes perennial ryegrass and subterannean clover, and Yorkshire fog and subterannean clover were obtained within three years of establishment. Italian ryegrass produced an excellent temporary pasture which failed to persist after three years and commercial perennial ryegrass produced a reasonably good stand during the first two years and then failed to persist.

After a 6-year period Phalaris tuberosa and Clunes perennial ryegrass were well established and growing vigorously and Yorkshire fog was beginning to die out.

Over the whole period there was very little difference between the carrying capacity of the three pastures, but during the drought period Phalaris was more productive than the other two species.

During 1941 all paddocks provided the same amount of grazing during the good season following the 1940 drought year.

This demonstration has shown the suitability of Phalaris tuberosa and Clunes perennial ryegrass and also the suitability of Yorkshire fog for this district over a 6-year period. It has also demonstrated the temporary nature of Italian ryegrass and the inferiority of commercial perennial ryegrass to Clunes certified perennial ryegrass as pasture species in this district.

This trial has served a valuable purpose in demonstration of the value of the various species to the farmers and much interest has centred upon it during the various field days when the attention of farmers was drawn to the results obtained from year to year.

ACKNOWLEDGMENT.

Grateful acknowledgment is made of the assistance given by Mr. V. Randell, Manager, Denmark Research Station, in respect of grazing, fertiliser, and general management, and for keeping the necessary records. Also acknowledgment is made of the assistance given by Mr. and Mrs. A. Millar, Forest Grove, for providing the land and assisting in the conduction of the trial.

Whey as a Food for Calves and Pigs.

V. WESTON, Dairy Instructor.

Whey is the by-product of a cheese factory, and its utilisation to the best advantage is an important part of the economy of dairy farming and cheese manufacture. As facilities in this State for drying and preparation of lactose are not available, this by-product must essentially be used as animal food. For this purpose it is particularly valuable for rearing calves and pigs.

With increasing cheese manufacture, large quantities of whey are available in Western Australia from June to January, and during past seasons much of this has gone to waste through a lack of appreciation of its possibilities. New Zealand underwent the same phase years ago when most of the whey went down the drains, but today due to experience and better information, many factories have installed scales to ration back whey to their suppliers.

There are different types of whey, but here we are concerned with one only, that which contains those substances in the milk serum not held up in the rennet coagulum, together with a small portion of curd broken up during the manufacturing process.

Whey is best fed in as fresh a condition as possible, when only a small percentage of lactic acid has been produced. Excessive acidity not only reduces the sugar content but will cause digestive disorders. A small handful of lime to every 40 gallons will correct the acidity and at the same time provide a very necessary mineral. Most factory managers arrange for the neutralising and the sterilisation of the whey, the latter arrests further fermentation or putrefaction and also safeguards the spread of disease germs. Separate holding vats are usually provided for pigs and calves.

The following table shows the solids analysis of whey, skim-milk, and whole-milk:—

	Whey.	Skim-milk.	Whole-milk.
Proteins	·8	3·1	3·45
Sugars	4·7	4·9	4·8
Fats	·3	·1	3·8
Ash	·7	·7	·75
Total Solids	6·5	8·8	12·8

From this it will be seen that whey contains 6·5 per cent. of solids as against 8·8 per cent. for skim-milk, and 12·8 per cent. for whole-milk, thus whey has about three quarters the feeding value of skim-milk and one half the value of whole-milk. It must not be assumed, however, that by feeding twice as much whey the same result as with whole-milk can be obtained. Animals overfed on whey give disappointing results with possible scours and bloating.

Whole-milk may be taken as a naturally balanced food, that is the solid constituents of protein, sugars, and fats are in the proportion most suitable for promoting the maximum growth or flesh gain. The nutritive ratio is 1 : 3·9, whereas with whey the ratio is much wider at 1 : 6·8. Therefore the stock feeder must narrow this ratio by adding suitable concentrates to the ration supplying those substances which are deficient.

In the article "Pigs, Breeding and Management," by G. K. Baron Hay, Leaflet No. 496, the subject of pig feeding is thoroughly dealt with, and nutritive ratios and balanced rations of various foods can be further studied; but here, the economical utilisation of whey is reviewed rather than the best methods of pig raising.

With whey the fats and proteins have been almost removed, and to bring one gallon of whey to the feeding value of one gallon of milk, it is necessary to add ⅓ lb. of fat and ¼ lb. of protein. This, however, is subject to modification in that good pasturage, hay, and concentrates should be available apart from swill feeding, and from these sources some of the deficiencies will be obtained.

The following are common concentrates with a high percentage of fats and proteins, which have been found suitable for balancing the whey ration:—

	Protein.	Sugars.	Fats.	N. Ratio.
Meat meal	48·4	nil.	10·2	1 : 0·5
Linseed meal ..	20·6	17·0	29·0	
Pollard	13·4	46·2	4·4	1 : 4·2
Wheat bran ..	12·5	41·5	3·0	1 : 3·9

A rich protein food such as meat meal is most desirable in the ration together with wheat, barley, oats, bran or pollard, to utilise the maximum amount of whey, or in other words, to raise the maximum number of pigs or calves from a given quantity of whey. This is important for those distant from the factory, as cartage is an expensive item.

It is difficult to arrive at the monetary value of whey, but we know that it is not so valuable as skim milk, as more concentrates are necessary for the same result. An interesting experiment was carried out in Canada which amply demonstrates its value. Two pens of twelve pigs were selected and fed for 120 days, one pen on whey and meal, and one on water and meal, the weights of the pigs and the quantities of food consumed were noted with the result below:—

Pen 1.—169 lb. meal and 747 lb. whey to produce 100 lb. weight increase and day gain of 1·16lb.

Pen 2.—430 lb. meal and water to produce 100 lb. weight increase and day gain of 0·7 lb.

Taking meal at 1d. per lb. there is a gross saving of £1 1s. 9d. per 100 lb. weight increase, and a much faster rate of maturity as well.

Other than meal, cartage costs will be the main item at present, as the whey is obtainable free. With those farmers carting milk to the factories and able to "back load" this is reduced to a bare minimum as also those in close proximity to the factory.

It must be noted that under the Dairy Industry Act and its regulations, cans used for the delivery of milk or cream must not be used for the carriage and storage of whey.

However, suffice to say that in recent extensive pig feeding trials on farms in New Zealand, using meat meal and whey, the average net value of the whey was ¾d. per gallon, or every gallon used on the farm realised a profit of ¾d. By rearing calves, a better return again is obtained.

FEEDING PIGS.

The following table is a simple guide to the quantities of meal and whey successfully used in New Zealand:—

	Whey gals.	Meal lb.
Sows before farrowing	6—10	2—3
After farrowing	10—20	3—4
Litters (per pig)	1 pt.—2½	2oz.—8oz.
Weaners and stores	2½—5	½—1
Porkers and baconers	5—8	1

In the above, meal contains at least half meat meal with the balance crushed grain, bran or pollard. The feeder must exercise his judgment, some pigs will utilise whey better than others.

Points to remember.

Feeding is often advocated five times daily, if possible, to enable the pigs to consume the large quantities of whey and so not overtax their digestive system.

Feed in as fresh a condition as possible, neutralise high acid with lime, and keep drums and troughs reasonably clean and throw out unused whey, don't keep till next day.

Make sure whey is sterilised at the factory to prevent introducing disease.

Make sure whey is not diluted with factory "washings," as diluted whey gives unsatisfactory results.

Stale acid whey can cause pigs to scour.

Pigs should have access to good pasture—grass provides useful roughage as well as minerals. It helps to limit the intake of whey and provides exercise.

Mix meal with whey just prior to feeding each meal rather than once for the whole day, this will restrict fermentation in the storage drums and allow all the pigs to get some meal.

Sudden changes in the rations should be avoided since whey contains a small quantity of highly concentrated dry matter and a large amount of water. Pigs on whey develop ravenous appetites and the intestines become accustomed to handling the small quantity of dry matter. If the ration is changed suddenly to solid foods, severe digestive disorders often set in with possible ruptures.

FEEDING CALVES.

Whey is a good substitute food for rearing calves and offers an excellent opportunity for those farms on whole-milk to rear calves and augment the income and ease the problem of herd replacements. It is a fallacy to think that skim-milk is essential for this purpose.

At Brunswick a number of farmers have successfully reared whey calves for some years, and the pioneering stage is definitely over. Messrs. Browne's, Ltd., Cheese Factory rear 30-40 calves yearly by the following method. Feed whole-milk for 14 days and then five per cent. whey and milk for 14 days, gradually increasing until calves will take all whey. Linseed meal was the concentrate used at the

rate of about ½ lb. per calf per day with from 1-2½ gallons of whey. The writer has seen these calves at all stages during the last two years and they have always looked well, notwithstanding the fact that insufficient pasturage was available.

Mr. J. Kasten is another successful rearer and his methods are outlined below.

Rears calf on whole-milk for one month and then straight on to whey, feeding about ¾ lb. of pollard to 1-1½ gallons of whey per day in two feeds. He does not believe in changing gradually to whey as the whey tends to curdle the milk (this could be corrected by the use of more lime). He finds calf takes to it as soon as properly hungry and without any ill effects. As the calf grows older whey may be increased up to 2-3 gallons. At all times Mr. Kasten has pasture, chaff, and bran available. He maintains the calves thrive better than on skim-milk and consume it with greater relish.

The methods recommended by A. C. T. Hewitt, M.Agr.Sc., Live Stock Science Officer of the Victorian Department of Agriculture, are condensed as follows:—

Calves to be fed whole-milk for two weeks. Next three weeks gradually replace by whey. For the best results mix ¼ lb. of linseed meal or a mixture of linseed meal and pollard with each gallon of whey fed; but whey only can be used, and by the sixth week the calves will do well on whey as the only bucket feed.

Feeding Table.

	Milk. lb.	Whey. lb.
First week up to	12	—
Second week	12	—
Third week	9	5–10
Fourth week	6	10–15
Fifth week	3	15–20
Sixth-twenty-fourth week	—	20–30

To be fed daily in two feeds and warmed to a temperature of 90°F.

It is essential that the whey be as fresh as possible, sterilised and undiluted.

Feed calves separately for best results and don't overfeed. Calves should be grazed on good pasture supplemented with good hay, chaff and concentrates.

REFERENCES.

"Facts About Whey," H. M. Pierson, Extension Officer in Pig Husbandry, New Zealand.

"Whey as a Stock Food," A. C. T. Hewitt, Livestock Science Officer, Victoria.

"Pigs and Their Management," H. W. Potts.

Management of an Apiary.

L. BLAIR, Government Apiculturist.

The management of the apiary is of vital importance to the apiarist, and determines in a great measure his returns in honey. To sum up, it is always necessary to have the hives strong just prior to a flow of nectar. Nectar, I might explain, is the exudation of flowers to entice insects to visit them, and in the process of visiting, these insects sup the sweet liquid, called nectar, and in exchange, the flowers become pollinated, as grains of pollen are caught in the hairs of the visitors' bodies and legs and thus transferred from the male to the female flowers. Thus nature works, and the flowers fertilised in this manner, set seed or fruit, sometimes both.

As can be readily understood, if the hive is not strong at the beginning of the flow, there is a large loss of honey. For illustrative purposes, we will suppose a hive is weak at the beginning of a flow. Honey and pollen is coming in; the Queen starts laying and everything is going along merrily inside the hive, with the young bees expanding in the brood nest, and plenty of both honey and pollen on which to feed them. Now comes the time factor, and this is in strict accordance with the average flow or blooming period of most flowers, say six to eight weeks. Some flowers of course, bloom over a longer, and some over a shorter period. Now compare this with the time factor in the hive. The Queen is governed in her egg-laying capacity by the food coming into the hive, and these eggs, from the time they are laid until they are hatched, take three weeks. When the young bees are hatched, there is a further period which they spend in the hive as they pass from one duty to another, such as acting as nurse bees to attend to the feeding of the younger bee life, and by the time they are old enough to take their turn at field work, there is a period of about 4½ to five weeks gone from the period of the honey flow. Consequently, the hive which was strong at the beginning of the honey flow should have gathered at least 30 to 60 lb. of honey, and will show at least double the return of the hive that started off from scratch, or when the flow first started.

There are also a number of other factors which govern the returns, i.e., the Queen, the frames, and the size of the hive. We will start with the Queen. It is always advisable to have a young, or good Queen, or, shall I say, a Queen who gives results, as some Queens, though old, are still good, and some young ones useless. It is advisable to cull out poor and indifferent Queens and replace them with prolific ones to obtain the best results. Culling Queens is a very good business, as it eliminates their bad characteristics. It comes very hard to kill a beautiful Queen, but after a reasonable trial it is the only sensible thing to do, as her bad properties may be transmitted through her male progeny, the drones, and in course of time, ruin the hive. To improve the hive and obtain the best results, this culling must be a continual process.

The frames also are a very vital factor if the best results are to be obtained, and these are bound up in the hive having the greatest amount of worker bees at the correct time. This cannot be attained if half the comb the Queen has at her disposal in which to lay is old, thick, unusable, and contains a large percentage of drone comb which should have been melted down years previously.

We will compare it this way: Take two hives. No. 1 has, we will say for comparison, 50,000 worker bees, and No. 2, owing to bad combs and reduced space for the Queen's lay, has 20,000 workers. It is obvious which will bring in the larger amount of honey. This same comparison also applies to the size of the hive. I

am not referring to standard sizes, such as the eight or 10 frame, factory-made article, or the usual nine-frame, home-made hive, but to the supers, and I will compare it this way:—

> *No.* 1 *hive.*—Is just a full-depth body, and we will call it the brood chamber.
>
> *No.* 2 *hive.*—Is one full-depth body or brood chamber, and one full-depth super.
>
> *No.* 3 *hive.*—Is a hive with a full-depth body or brood chamber and two full-depth supers. We will assume that the three hives in question are headed by three good Queens, one in each, and the combs and hives are good average ones. Now we will examine results.

No. 1. *The single hive.*—The bees get busy when the flow starts, and quickly fill up the single apartment which is at their disposal, and they cannot expand or store any more honey, brood, or pollen. Result, they will either swarm to escape the small house, and seek increased accommodation, or if towards the autumn, they will just loaf, and sit about the entrance and wait for the winter. Then perhaps the owner may decide to do a little extracting, and on opening the hive gets one or two frames of honey on the sides, which may amount to 10 or 12 lb. in weight, and the rest of the frames are all filled with brood and pollen (Gain —12 lb. honey).

No. 2. *The double hive.*—This hive gets busy like No. 1, and fills the bottom body and this time, just prior to the bottom body being filled, the apiarist adds a super, taking out a frame from the nearly filled body and placing it in the super, and replacing an empty brood comb in its place from the super. This comb from the bottom body acts as a bait, and induces the bees to expand into the super, and the work progresses. In a short time, the super is also filled, and as with No. 1, the apiarist then does some extracting. This time, he will probably be able to extract seven or eight nicely capped honey frames, which will weigh in the vicinity of 35 lb. (Gain—35 lb. honey).

No. 3. *The treble hive* (with extra full-depth super).—This hive starts off with the others, and a similar process is followed as with No. 2, save that a second super is added just prior to the first super being filled. This hive will take a little longer to fill the two supers, but they, with extra storing space for ripening the nectar, and more room for the Queen to lay in, have the advantage in many ways, particularly if the apiarist is late in extracting, as the other two hives are full and loafing, and the three-decker is still working and storing honey.

However, the apiarist extracts in due course, and from the three-decker, he will take 12 to 15 frames of honey, say 75 lb. (Gain—75 lb. honey).

By this comparison, I do not wish to infer that the addition of supers can go on indefinitely, but it is preferable to add supers in the event of the bee-keeper being too busy to extract, rather than have the bees loafing.

In the United States supering is carried to seven and even nine frames, but this requires a great deal of extra equipment, and introduces the risk of toppling over. I think the three-decker an admirable all-round utility size, as a good hardy strain of bees in normal years can protect this size throughout the year in Western Australia.

Further information may be obtained by writing to the Department of Agriculture on any subject dealing with management of the apiary, and bee-keeping in general.

Agricultural Broadcasts.

The following programme of Agricultural talks has been arranged for the July-September quarter and will be broadcast from Stations 6WN and Regionals at 7.15 p.m. each Tuesday.

Date.	Talk Prepared by:	Title.	Summary.
	I.—FARMERS IN A CHANGING WORLD SERIES.		
July 27	Dr. E. J. Underwood, Animal Nutrition Officer in the Department of Agriculture, and Chairman State Nutrition Committee	Implications of the United Nations Food Conference, Part I.	The reasons for calling the Conference and its historical background will be outlined together with a discussion of the conference findings and their implications for the immediate post-war world.
Aug. 24	do. do. do.	Implications of the United Nations Food Conference, Part II.	The implications of the Conference for Australian Agriculture and Australian standards of nutrition will be discussed.
Sept. 21	Mr. G. H. Burvill, Assistant Plant Nutrition Officer in the Department of Agriculture	Changing Ideas on Soil Cultivation	Soil cultivation is an art with centuries of tradition. Clean and regular cultivation has been regarded as good practice in farming and gardening. But scientific experiments do not support many traditional ideas and the menace of soil erosion also calls for changes in cultivation methods.
	II.—TOPICAL ITEMS.		
July 6 Aug. 3 Aug. 31 Sept. 28	Mr. G. K. Baron Hay, Under Secretary for Agriculture will discuss current events of importance to the farmer		
	III.—FARMER'S FORUM.		
July 13 Aug. 10 Sept. 7	Discussion will be arranged by Dr. G. A. Currie, Professor of Agriculture in the University of Western Australia, on topics submitted by farmers		
	IV.—TECHNICAL TALKS.		
July 20	Mr. C. F. H. Jenkins, Government Entomologist, Department of Agriculture	The Sheep Blowfly Problem	A brief description of the flies concerned in the problem will be given, together with details of their life histories and habits. The latest recommendations for the treatment of fly strike will also be described.
Aug. 17	Mr. E. T. Morgan, Officer-in-Charge of the Potato Branch, Department of Agriculture	Seasonal Hints for the Home Vegetable Garden	
Sept. 14	Mr. H. G. Cariss, Agricultural Adviser, Wheat Branch, Department of Agriculture	Fodder Conservation in the Wheat Belt	Methods of conserving fodder and how to feed it to animals.

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Experiments with Micro Elements for the Growth of Crops in Western Australia.

IX. COPPER DEFICIENCY OF CURRANTS AT GINGIN AND ITS CORRECTION.

*L. J. H. TEAKLE, *H. K. JOHNS, and †A. G. TURTON.

SUMMARY.

The unthrifty growth of currants and sultanas in certain vineyards at Gingin has been found due to copper deficiency.

Rehabilitation of the vines may be effected by copper sprays, by the use of copper fertilisers, or, preferably, by a combination of these treatments.

Vines, replanted after removal of the affected vines, make rapid growth when treated with copper.

When sampled in December, leaves of copper-deficient vines contain two to four parts per million of copper on the dry basis. Normal leaves contain about twice this amount.

No evidence of any other mineral deficiency was detected.

I.—INTRODUCTION.

For many years, fruit trees and grape vines have been grown at Gingin without any general symptoms of unusual nutritional disorders. In fact, in the early part of this century, Gingin held a reputation throughout Western Australia for the high quality of its citrus products. When farmers were able to divert their attentions more profitably to stock raising, the importance of fruitgrowing in the district waned and many orchards went out of production.

In 1933, a number of farmers in the Moondah Brook section, east of the township, planted areas of currants and sultanas. These plantings were on three of the main types of soils in the district, described by Hosking and Greaves (1936) as the Whakea sand, the Koorian sand, and the Ballingah sandy loam.

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† Chemist, Government Chemical Laboratory.

In three of these vineyards the growth of the vines proved very unsatisfactory over considerable areas in spite of the apparent suitability of the soil with respect to texture, depth, permeability and drainage. As a result of the representations of

Fig. 1.

Six-year-old sultana vines on Mr. V. G. Rennie's property, Gingin, photographed 28th April, 1939.

Upper: Vigorous vines on Ballingah sandy loam near the drying shed. Lower: Unthrifty vines in the same row, but on Whakea sand.

Mr. L. Thorn, M.L.A., two of the authors inspected these vineyards in April, 1939, to investigate the soil conditions, as there was no evidence of disease resulting from fungus or insect attack which could be held responsible for the unthrifty growth. In fact, the vineyards had been singularly free from fungus diseases and the usual copper sprays had never been used. The significance of this will become apparent later. At this inspection, it was observed that sultanas generally made more vigorous growth than currants but, with the exception of certain favoured patches, in no instance had either variety proved satisfactory and in many cases the growth was extremely poor. Even where the vegetative growth was more satisfactory, the rooting system appeared to be very weak and subject to the attack of secondary fungus growth.

Figure 1 is a photo from the late Mr. V. G. Rennie's vineyard, Moondah, Gingin, which shows the contrast in the growth of sultana vines in different parts of the plantation. The vigorous vines may be regarded as normal for a young vigorous vineyard, but the unthrifty vines are suffering from some disability.

Figure 2 depicts the condition of the rooting systems of some of the better grown, but still somewhat unthrifty, currant vines from another portion of the vineyard which was selected for an experiment to determine the effects of various treatments on replants. These vines were dug out to make way for the new ones.

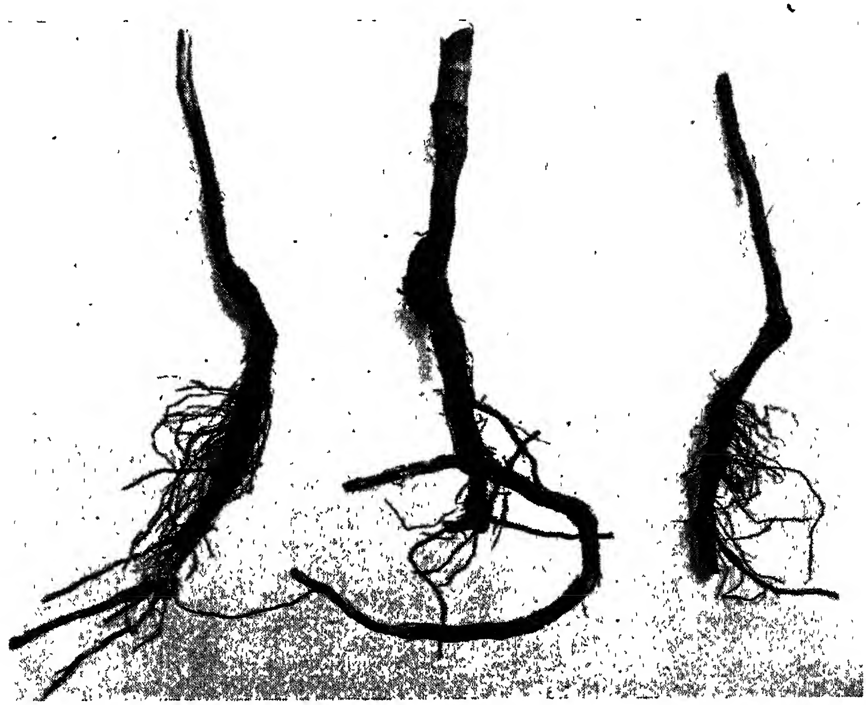

Fig. 2.
Rooting systems of six-year-old, fairly well grown currants on copper deficient Whakea sand on Mr. V. G. Rennie's property, Gingin. Note the evidence of secondary roots on the main roots and the abnormal development of adventitious roots at or near ground level.

Examination showed that, in five years, the vines, in the most severe cases, had only just reached the bottom wire about 2½ feet from ground level. The stems were little more than a half inch in thickness and the bark looked rough

and unhealthy. The canes were very short, internodal growth was severely restricted, and the wood did not mature normally. Further, the leaves were small, only slightly indented, and pale in colour due to a mild chlorosis. Where the growth of the vines was somewhat better, but still not normal, similar symptoms were observed but in a much milder form. In the portions of the vineyards where the soil conditions apparently were suitable, quite vigorous growth had been made and in some instances sultana canes were as much as 20 feet long. (Fig. 1.) In all respects these vines appeared normal and very vigorous.

Unfortunately, the bulk of the vineyards carried vines more or less unthrifty, due to some disorder. The symptoms were not definitely indicative of any particular deficiency, but in view of the discovery of copper deficiency in this area by Bennetts and Chapman (1937), the possibility of the trouble being nutritional was suspected. In consequence, normal mature leaves from vigorous and from unthrifty vines representing both currants and sultanas were selected from two of the properties. These leaves were examined spectrographically by Mr. F. E. Chapman of the Government Chemical Laboratory. His report indicated that with respect to manganese, magnesium, sodium, potassium, calcium, iron, and boron, no outstanding differences could be detected between leaves from the vigorous and unthrifty vines. There was a substantial difference, however, in the intensity of the copper lines indicating that the leaves of unthrifty vines were very much lower with respect to this element. Chemical analyses were made for ash and copper content with the results given in Table 1.

TABLE 1.

Analyses of Vigorous and of Unthrifty Sultana and Currant Vines on the Properties of Mr. V. G. Rennie and Mr. H. P. Bateman, Gingin.

Sampled 28th April, 1939.

Lab. No.	Description of Vines and Soil Type.	Ash.	Copper p.p.m. Cu dry basis.
1. V. G. Rennie—			
Sultanas:		%	
2773	Strongly growing vines on Ballingah sandy loam near drying shed	9·5	3·9
2774	Poor vines on Whakea sand	11·3	1·8
2775	Very poor vines on Whakea sand near dam ...	11·8	1·4
Currants:			
2778	Fair vines on Ballingah sandy loam	10·0	2·6
2777	Poor vines on Ballingah sandy loam	12·9	1·6
2776	Very poor vines on Whakea sand	13·5	1·7
2. H. P. Bateman—			
Currants:			
2779	Good vines growing on old rubbish pit on Koorian sand	10·4	2·8
2780	Poor vines on Koorian sand	10·5	1·2

The figures in Table 1 show that, for both currants and sultanas, the vigorous vines are considerably richer in copper than are the unthrifty ones. The percentage of ash shows no consistent variation.

This information formed the basis of a diagnosis being made that copper deficiency was the prime cause of the unsatisfactory growth in these vineyards. In order to check this diagnosis and to study means of correcting the disorder, Mr. Rennie agreed to co-operate in experimental work in his vineyard. Currants were selected for the purpose and arrangements were made to use fertiliser and spray treatments on old vines in one portion of the vineyard and, in a contiguous portion, on replants established on the sites from which the old vines had just been removed.

II.—THE EXPERIMENTS.

In much of the area selected for the experiment to determine the value of treatments in effecting recovery, the condition of the vines was such that it was thought that some years would elapse before any response could be expected. In fact, the opinion was expressed that these vines were past recovery at all, and better results would be obtained by pulling them out and replacing them with new stock. This aspect was studied in the block where the old vines were uprooted and new ones planted.

For application of the treatments, alternate rows of vines were taken so that there would be a buffer row of vines between each row under treatment. Each plot consisted of five vines and one vine was left as a buffer in the row between successive plots. Throughout the experiment, ordinary orchard practice and manuring were applied and the special treatments superimposed. At the commencement of the experiment, notes were made on the size and vigor of each vine under experimentation so that it was possible to evaluate changes occurring during the treatment.

The treatments were:—

A. *The Recovery of Old Vines.*

Treatment 1—Control, normal vineyard practice.

Treatment 2—Dormant spray, 15 lbs. of bluestone in 40 gallons of water, applied in August.

Treatment 3—Dormant spray in August plus foliage spray of Bordeaux mixture 6 : 6 : 40, applied in October and December.

Treatment 4—Four ounces of bluestone per vine applied to the soil immediately around the vine in early September.

Treatment 5—Four ounces of bluestone per vine as in (4), plus foliage sprays of Bordeaux mixture 6 : 6 : 40 in October and December.

Treatment 6—Four ounces of bluestone plus four ounces of manganese sulphate per vine in early September.

Treatment 7—Four ounces of bluestone plus four ounces of manganese sulphate plus one ounce of zinc sulphate per vine in early September.

Treatment 8—As (7) plus foliage sprays of Bordeaux mixture 6 : 6 : 40 in October and December.

B. *Replanted Vines.*

Treatment 1—Control, normal vineyard practice.

Treatment 2—Foliage sprays of Bordeaux mixture 6 : 6 : 40 in October and December.

Treatment 3—Four ounces of bluestone per vine applied to the soil around the vines in early September.

Treatment 4—Four ounces of bluestone per vine, as in (3), plus foliage sprays of Bordeaux mixture 6 : 6 : 40 in October and December.

Treatment 5—Four ounces of bluestone plus four ounces of manganese sulphate, plus one ounce of zinc sulphate per vine in early

Treatment 6—As (5) plus foliage sprays of Bordeaux mixture 6 : 6 : 40 in October and December.

The special soil treatments were applied in 1939, 1940, and 1941, and then discontinued. Dormant and foliage sprays were continued throughout this period and in 1942, which season marked the conclusion of the experiment.

During this period, each year the orchard received either blood and bone fertiliser, or a special mixed manure rich in potash, at the rate of 3 cwts. per acre. Each year the land was ploughed in August or September at the time of the application of the general fertiliser, and cultivated subsequently as necessary. Mature leaves were sampled in December of each year of the investigation and analysed for copper.

In December, 1939, the first year of the experiment, samples of the mature, vigorous leaves taken for copper analysis were also examined for general chemical composition. At the same time, similar samples were obtained from vines on the property of Mr. Eric Stevens of Bindoon, which were planted in the same year but which had made exceptionally vigorous growth and were proving high producers.

These leaf analyses are given in Table 2.

TABLE 2.

Mineral Composition of Leaves and Leaf Stalks from Currant and Sultana Vines grown at Gingin and Bindoon.

Vines Planted 1933 ; Leaves Sampled December, 1939.

Lab. No.	Special Soil Treatment.	Leaf Composition (on Oven Dry basis).						
		N.	P.	K.	Ca.	Mg.	Mn.	Cu.
1. *Currants*—		%	%	%	%	%	p.p.m.	p.p.m.
(A) V. G. Rennie, Gingin:								
135	¼ lb. Bluestone per vine, 1939 ...	2·41	0·19	1·10	1·66	0·41	116	2·9
136	¼ lb. Bluestone per vine, 1939 ...	2·32	0·17	1·19	1·75	0·34	90	2·9
137	None	2·43	0·23	1·12	1·97	0·40	96	3·1
138	None	2·29	0·22	1·09	2·00	0·38	88	2·5
(B) E. Stephens, Bindoon:								
142	None	2·75	0·17	1·20	1·96	0·49	73	9·8
143	None	2·67	0·16	1·17	2·19	0·42	38	7·9
144	None	2·85	0·16	1·10	2·44	0·47	45	9·9
2. *Sultanas*—								
(A) V. G. Rennie, Gingin:								
133	¼ lb. Bluestone per vine, 1939 ...	2·46	0·23	1·32	1·17	0·67	113	2·1
134	¼ lb. Bluestone per vine, 1939 ...	2·25	0·18	1·22	1·34	0·66	166	2·9
131	None	2·32	0·26	1·32	1·88	0·72	160	3·8
132	None	2·31	0·21	1·18	1·52	0·56	164	5·4
(B) E. Stephens, Bindoon:								
139	None	2·48	0·19	1·39	1·88	0·49	120	8·1
140	None	2·63	0·17	1·61	1·98	0·42	70	7·9
141	None	2·52	0·17	1·58	1·78	0·43	46	7·5

These data show that the Gingin samples are exceptionally low in copper as compared with those obtained from Bindoon but the other elements are similar in concentration. Minor variations occur as, for instance, with respect to magnesium, but there appear to be no consistent differences except with respect to copper.

Recovery of Old Vines.

During the 1939-40 season, no effect of treatment was observed, either on the appearance of the vines or on the copper content of the leaves.

The next growing season, 1940-41, revealed a slight improvement in the appearance of the foliage of the sprayed vines and, at pruning, the wood on these vines was found to have matured much more satisfactorily than elsewhere. Soil treatments alone had not yet affected the appearance of the vines and analyses showed that the copper content of the leaves was still low and similar to that of the control vines. Beneficial effects from the treatments, particularly where Bordeaux sprays were applied, were apparent in 1941-42.

Parallel with this improvement in appearance where bluestone had been applied to the soil was the increase in the copper content of the leaves. This treatment raised the copper content of the leaves to a concentration generally similar to that observed in the healthy vines from Bindoon. The delay in this effect is thought to be due to the very poor rooting systems of the vines resulting from the severe copper deficiency suffered. Further improvement was noted in 1942-43 and the beneficial effect of the copper treatment either as spray or as a soil treatment was established by the copper content of the leaves, yield of fruit, weight of prunings, and general appearance.

Table 3 gives the changes in copper content of the leaves from control and bluestone treated vines during the experiment.

TABLE 3.

Copper Content of Currant Leaves Sampled in mid-December in 1939, 1940, 1941, *and* 1942, *from old Experimental Vines in Mr. V. G. Rennie's Vineyard, Gingin.*

Plot.	Treatment.	Copper p.p.m. Cu. Dry Basis.			
		Dec., 1939.	Dec., 1940.	Dec., 1941.	Dec., 1942.
Old	*Vines—Planted* 1933—				
6	Control	...	3·9	2·7	13·0
8	Bluestone, ¼ lb. per Vine in 1939, 1940, and 1941	...	3·7	8·5	12·8
11	Control	...	2·8	2·7	9·1
12	Bluestone, ¼ lb per Vine in 1939, 1940, and 1941	...	4·1	6·4	10·3
20	Control	3·1*	3·5	1·8	5·3
		2·5*	...	...	...
21	Bluestone, ¼ lb. per Vine in 1939, 1940, and	2·9	3·8	6·0	11·2
	1941	2·9	...	...	...
26	Control	...	4·5	3·5	7·4
31	Bluestone, ¼ lb. per Vine in 1939, 1940, and 1941	...	6·4	5·2	12·5

As expected, the leaves sampled in December, 1942, from vines receiving bluestone on the soil were moderate to high in copper content, the range being 10.3 to 12.8 p.p.m. It was quite unexpected, however, to find that the leaves from the control vines, not directly treated with copper in any form and not showing obvious signs of improvement, were very much higher in copper than in previous years. The range was 5.3 to 13.0 p.p.m. of copper.

It is difficult to explain the high copper contents of the leaves from the control vines in 1942-43. As other parts of the vineyard had been sprayed for the first

* Sampled untreated buffer row adjacent plot 21.

time a few weeks earlier to control anthracnose, it is thought that slight contamination from these sources may have occurred. Cuprox was used as the spray and is very rich in copper.

The yields of fresh fruit were obtained in the 1941-42 and the 1942-43 seasons and the weight of the prunings in the latter. These data, together with a figure representing the vigour of the vines under each treatment at the commencement of the experiment in 1939, are given in Table 4.

TABLE 4.

Vigour Grade of old Vines at beginning of Experiment in 1939 expressed as per cent. of the grade given to normal vigorously-grown Vines of the vineyard, yields of fresh fruit per Vine in 1941-42 and 1942–43 Seasons, and weight of prunings in 1942–43 Season resulting from various fertiliser and spray treatments.

No.	Treatment.	1939 Season.	1941–42 Season.	1942–43 Season.	
		Vigour Grade of Vines to be Treated.	Weight of Fruit per Vine.	Weight of Fruit per Vine.	Weight of Prunings per Vine.
		%	lbs.	lbs.	ozs.
1	Control	54	9·6	5·3	17
2	Dormant spray	58	21·1	8·9	38
3	Dormant spray, Bordeaux spray	36	6·6	8·6	44
4	Bluestone fertiliser	43	11·8*	6·4*	34*
5	Bluestone fertiliser; Bordeaux spray	59	16·6	9·7	41
6	Bluestone and manganese fertiliser	67	14·9	9·1	37
7	Bluestone, manganese, and zinc fertiliser	52	12·4	8·2	39
8	Bluestone, manganese, and zinc fertiliser; Bordeaux spray	63	13·7	11·2	43

* One plot gave very little fruit or prunings in 1942–43 season. These vines had been the most unthrifty of the series in 1939 and recovery proved slow but nevertheless spectacular.

The yield data were very variable from vine to vine and, while indicating benefit from copper treatment, are not considered very conclusive. It must be remembered that these vines are now recovering from a severe setback owing to copper deficiency and many factors will influence yield of fruit. The vegetative response, shown by the weight of prunings, will be a much more certain measure of the effects of the treatments. All copper treatments have effected substantial recovery and there is an indication that the sprayed vines have attained an added advantage over those receiving soil treatments only.

The vegetative response was spectacular in the eastern part of the vineyard where the vines had been most unthrifty in 1939. Here the buffer vines receiving no copper made practically no progress in the 1939-1943 period. Vines receiving copper as a spray or as a soil treatment recovered, and, by the 1942-43 season, were more or less normal in size and appearance for ten-year old vines.

Figures 3 and 4 illustrate the response of these vines to the treatment.

Establishment of replant vines.

The vines in the replanted section, in spite of competition from the established vines surrounding them, made good progress where copper treatments were applied

either to the soil or as sprays. The controls, on the other hand, made poor growth and did not appear to be as vigorous as the old vines which had been uprooted immediately prior to their planting.

Fig. 3.
General view of the vines in the portion of Mr. V. G. Rennie's vineyard on Whakea sand where, under normal vineyard practice, currants failed to grow satisfactorily—see the front row—and where the application of copper sprays in four successive years resulted in recovery of the affected vines as indicated by the vigorous growth in the row immediately behind. Vines ten years old.

Observations were made during the period of the experiment but these cannot readily be expressed quantitatively. It is to be noted, however, that in the fourth season (1942-43) some of the treated vines were large enough to be cinctured and produced a small amount of fruit. As with the old vines, the production of wood, as indicated by the weight of prunings, is deemed to be the most reliable index of response. These weights were determined in 1942-43 and are given in Table 5.

TABLE 5.

Effect of Fertiliser and Spray treatment on the establishment of Replant Vines in the Vineyard

Replanted 1939. Prunings weighed June, 1943.

No.	Treatment.	Weight of Prunings per Vine.
		ounces.
1	Control	10
2	Bordeaux sprays	30
3	Bluestone fertiliser	32
4	Bluestone fertiliser; Bordeaux spray	45
5	Bluestone, manganese, and zinc fertiliser	30
6	Bluestone, manganese, and zinc fertiliser; Bordeaux spray	35

Fig. 4.

Close up of representative vines from treated and untreated rows shown in Fig. 3. Upper: Ten-year-old currant under normal vineyard practice. Lower: Recovery and growth resulting from application of copper sprays (dormant and Bordeaux) in four successive years in addition to normal vineyard practice.

Growth of the vines, as measured by the prunings, has been at least trebled by copper treatment. This increase in quantity of growth is paralleled by the improved health and more thrifty appearance of the copper treated vines and is illustrated by the contrast shown by figure 5. These photos were taken on 21st

January, 1943, and both vines represent four seasons' developments. Figure 6 shows the type of prunings obtained from control and copper treated vines. From Table 5 it seems likely that soil treatment with copper combined with a copper spray is most effective.

Fig. 5.
Four-year-old replant vines in Mr. V. G. Rennie's property, Gingin.
Upper: Plot 1—Under normal vineyard practice. Lower: Plot 4—Growth resulting from application of bluestone to the soil at 4 ounces per vine in 1939, 1940 and 1941, in addition to normal vineyard practice.

Fig. 6.

Prunings from three-year-old replant vines in 1942. (See Fig. 5 for 1943 growth.)
Left: Plot 1. Control—ordinary vineyard practice. Canes generally short and wood poorly matured.

Right: Plot 4. Bluestone ¼ lb. per vine in 1939, 1940, and 1941, in addition to ordinary vineyard practice. Canes well grown and generally vigorous. The small canes on the left are 20 in. long.

The copper content of the leaves of replant vines from control and copper treated plots is shown in Table 6.

TABLE 6.

Copper Content of Leaves from Vines Planted in 1939 *after the Uprooting of the Original Crop.*

No.	Treatment.	Dec., 1941.	Dec., 1942.
1	Control	3·7	13·0
4	Bluestone, ¼ lb. per vine in 1939, 1940, and 1941 ...	8·0	11·8
5	Bordeaux spray twice annually	17·8*	...
8	Control	3·9	...
11	Bluestone, ¼ lb. per vine in 1939, 1940, and 1941 ...	10·0	...
12	Bordeaux spray twice annually	34·1*	...

* Sampled leaves grown since the October spraying and immediately before the December spraying. It seems likedly that these leaves have been slightly contaminated by contact with, or dust from, the sprayed leaves.

In the 1941-42 season, the control vines were low in copper—3.7 and 3.9 p.p.m.—but the soil treatments had resulted in a normal copper content—8.0 to 10.0 p.p.m. The response was obvious. Leaves from vines sprayed with Bordeaux two months earlier were much higher in copper, probably due to slight contamination by contact with or dust from the older lower leaves. In this sampling, care was taken to select mature leaves from portions of the vines which had grown since the spraying. Leaf samples taken in December, 1942, from the control and copper treated vines shown in Figure 5, were both high in copper. This, also, is suggestive of contamination by copper-containing dust blown from parts of the vineyard sprayed earlier with Cuprox, because the control vines were still very unthrifty and gave no sign of recovery.

III.—DISCUSSION.

These investigations establish the incidence of copper deficiency as the cause of unthrifty growth of vines at Gingin.

Chemical analyses show that mature currant and sultana leaves, from country on which vigorous growth is made or where copper fertilisers have been used, contain from 7.5 to 10.0 parts per million of copper on the dry basis when sampled in mid-December. Where the vines are suffering from copper deficiency the leaves contain from 2 to 4 p.p.m. of copper when sampled at the same growth stage. These figures are in close agreement with analyses given by Oserkowsky and Thomas (1938) for leaves of pears, and by Dunne (1936) for leaves of apples, affected by copper deficiency. There is evidence that leaves sampled in April—at the end of the season—are much lower in copper. However, from the more acutely deficient vines, leaves are lower in copper (1-2 p.p.m.) than from the vigorous or normal ones (2-4 p.p.m.).

The December period seems suitable for sampling leaves for diagnostic purposes. The fruit is just forming and an abundance of vigorous, mature leaves, showing no sign of senility, can be obtained.

The spectrographic and general analyses indicate that the leaves are normal with respect to a considerable number of elements and that copper deficiency is the only condition at all acute.

This conclusion is supported by the experiments with various special fertilisers and copper sprays. The inclusion of manganese or of manganese and zinc with the bluestone produced no obvious benefit. Copper sprays gaxe an earlier improvement in appearance and proved equally as effective as soil treatments in relieving the deficiency. There is a suggestion that copper sprays combined with copper fertilisers are the most effective control.

The experiments showed that six year old vines, very unthrifty on account of copper deficiency, were renovated by the copper treatments but 3 to 4 years elapsed before the recovery was substantial. It is thought that deterioration of the rooting system due to the deficiency, rendered the vines incapable of rapid response.

The replanted vines showed vigorous establishment on the sites of the old vines when treated with copper. This establishment was effected although planted in rows adjacent to vines already in their sixth year. Apparently, owing to copper deficiency, the competition from these older vines was negligible.

The copper deficiency affects the growth of the vine generally. The rooting system is poor and the annual production of adventitious roots at or near the surface of the soil is characteristic. The stem growth is restricted and the bark rough and unhealthy. Leaves are small and pale in colour, the canes are short

with short internodes, and the wood matures badly. Fruiting is shy and the quality poor.

Copper deficiency is readily controlled by annual copper sprays and by the use of copper-containing fertilisers. As a soil dressing, one application of bluestone at the rate of 1 cwt. per acre should be adequate for several years.

The authors wish to express their appreciation of the assistance of the late Mr. V. G. Rennie, who made available part of his vineyard for the work and incurred considerable expense in the replanting of portion of the experimental area.

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Breech and Tail "Strike" in Sheep.

MULES OPERATION TECHNIQUE AND OTHER FACTORS.

W. L. McGARRY, Sheep and Wool Adviser.

The predisposition of sheep to crutch strike is due to the definite physical character of the sheep itself and it is now well established that the conformation of the breech is one of the main factors in predisposing sheep to crutch strike.

In dealing with the problem of blow-fly control the first necessary step is to remove or reduce the inherent predisposition of sheep to "strike." Sheep are not struck by accident or chance; they are struck deliberately because by nature and conformation they are predisposed towards fly strike. It follows that the more faulty the breech conformation the greater are the chances of sheep becoming struck.

Fly strike is a condition of parasitism and effective strike cannot occur in the absence of free moisture at the site of deposition of eggs by the fly. Generally it can also be said that serious fly strike cannot occur unless the primary fly is present in sufficient numbers.

There are three ways of removing or reducing the natural or inherent predisposition of sheep to strike. They are:—

1. Selective breeding.
2. The Mules operation.
3. The "long" tail.

While selective breeding, or gradually breeding away from wrinkly breeched sheep, can achieve much, it is obvious that this method offers little *immediate* relief from the devastation of fly strike. Although as a long range policy it should not be neglected a note of warning is sounded here of the danger of breeding light plain sheep. The reversion to lightness has always to be fought and no grower desires to lighten the wool on his sheep. It is interesting to point out here that research workers have made the almost incredible finding that merino wool fibres, plus their sweat and fat glands, occupy only from 5 to 8 per cent. of the skin area on a sheep and therefore at least 92 per cent. of the skin is bare. In the medium wool types, the evidence appears to indicate that we have to guard against a reversion to "plain and light" in sheep with too tight a skin that fits like a glove.

The fibres on such sheep also invariably receive very little protection from dust and weathering. Of course the type of sheep with a skin that tends to looseness and slight breech pucker should not be confused with the wrinkly and wrinkly short fatty-woolled types which are an abomination and always to be avoided. The aim should be a warp wool showing quality and desirable characteristics and processing into a good weight of *scoured product* on a well set and compact sheep. Given this, we should not worry unduly regarding some breech pucker.

Fig. 1.
Sheep before treatment.

The value of the second method, that is making the breech of the sheep plain artificially by the Mules operation, is undoubted. The Mules operation is now regarded by research workers as the biggest single means so far discovered towards control of breech strike and breech strike accounts for 90 per cent. of the losses due to blowfly strike. The Mules operation consists of the removal of the wool bearing folds, and loose skin about the centre of the breech, and on each side of the vulva, which are both most likely to be soiled by urine or dung. By this removal the skin is tightened and better drainage is achieved. The Mules operation does not involve the removal of *all* the folds about the breech, or tail. The operation is not harmful to the sheep and can be performed on sheep of any age and the effect is permanent for the life of the animal.

In performing the Mules operation the aim is to achieve—

1. The removal of the wrinkle and loose skin from the crutch of the sheep.
2. The stretching out of the bare area below the tail.

Fig. 2.
Sheep immediately after treatment.
Faults.—1. Not drastic enough. 2. Cuts start too high up from butt of tail.

These objects are achieved by drastically cutting away two crescent-shaped pieces of skin on either side of the vulva, whilst at the same time taking care to avoid cutting the bare area on either side of the organ. It is very necessary to avoid reducing the total area of the bare area by accidental cutting, as the ultimate aim is to achieve the maximum stretching of this bare area. Faulty cutting in this respect is avoided by running the shear blade just to the edge of the bare area, but not cutting into it. The cuts should taper at each end to a definite point. "Square end" cuts delay healing and what is more important invariably pucker up and heal with pockets which retain moisture and attract blowflies. The points on the cuts can be achieved by picking up the skin with the shears when starting the cut, and when finishing by bringing the shears slightly away from the body and letting them gradually run out of the skin towards the end of the cut. The aim

is to achieve two clean cuts without ragged edges. If the shears are allowed to run out of the skin before the cut is completed a second continuing cut becomes necessary. This results in an uneven or ragged edge which puckers up and delays healing. A second cut also usually causes the sheep to struggle unduly, owing to the extra momentary pain and the longer period occupied in removing the necessary skin. These factors are eliminated with one quick clean cut.

The cuts should start evenly, well down on the butt of the tail and at about the same distance from the midline of the back. If the cuts start unevenly the bare area will be drawn out unevenly resulting in the woolled skin being brought close to the vulva. It is necessary for the cuts to start at about the same level with a point and work in towards the bare area and then turn to run down the inside of the breech. The cuts should be widest about the middle and opposite the vulva. This achieves a maximum stretching of the bare area and de-wrinkling of the crutch.

It is found that beginners are invariably not drastic enough and naturally somewhat clumsy when first attempting the treatment. After correct demonstration and explanation, however, and when a few sheep have been treated this simple operation can be efficiently performed and speed is attained with practice. Examination of the sheep as they run away from the operator is advised in order to observe the faults that are being made.

To obtain maximum results from the Mules operation it is necessary to remove sufficient skin to shock anybody who is witnessing the operation for the first time.

It is definitely recommended that *all* female sheep be treated. Examination of many "plain" sheep has revealed that a large majority of them possess some surplus of loose skin in the breech. Quite apart from stretching their "bare area," it has been found that the weight of the wet (urine and rain) and dag laden wool pulls this loose skin down slightly and forms channels which retain moisture and create an attraction for the "fly" and a harbourage for maggots similar to that of definite folds or wrinkles.

It is recommended that the operation be carried out in conjunction with lamb marking. The earlier the operation is performed the greater will be the economic benefit as the protection will extend over the *whole* life of the sheep. In addition, lambs heal quicker than adult sheep and less labour is involved if the lamb is treated whilst on the rail for marking. Probably it would also be convenient to treat lambs immediately after shearing or at weaning time. If the operation is carried out at weaning time it will be necessary to crutch the sheep as the presence of wool masks the folds and prevents the operation being performed successfully. The operation can only be performed successfully on sheep that have been crutched or shorn within a week or so. If the operation is carried out at lamb marking time treat all ewe lambs. When there are older lambs with longer wool in the drop, probably due to a protracted lambing, a more efficient treatment will be achieved by crutching these lambs before operating. When treating lambs remove the folds and loose skin before the tail is docked.

The operation should not be carried out when flies are active. If circumstances preclude the treatment during cold weather when flies are absent it is advisable to operate during periods of dry weather and dry feed conditions when flies are comparatively few in numbers.

Recent experiences in the pastoral areas indicated the value of treating adult sheep when sufficient labour is available to handle the sheep. When little labour is available and to save lifting, the operator could stand outside the shed opposite

to the exit in a counting out pen in cases where the shearing shed is above ground level. Combined crutching and "Mulesing" could be carried out in this manner. In sheds of this type fast, clean treatment with a minimum of labour can be achieved by removing a square of grating (replaceable later) in a large holding or sweating pen in the body of the shed. By lowering himself in this temporary pit, the operator is in a convenient position to all the sheep which merely require catching and turning. Another suggestion to save lifting is that a small pit be dug adjacent to a crush pen in temporary sheep yards. With the operator standing in the pit he would be working level with the sheep. A floor grating or sleepers in the crush pen has proved a decided advantage under these conditions. If possible it is considered advisable not to operate in old sheep yards owing to the risk of infection due to the dust coming in contact with the wounds.

There are three important things to remember when performing this operation. Firstly, *the Mules operation can be a complete failure if it is not carried out correctly*. Secondly, *remove plenty of skin*. Thirdly, *do not perform the operation when flies are abundant and active.*

Fig. 3.
Treated sheep showing stretched bare area.

Another decided advantage of the Mules operation, is that it makes crutching much more effective and simpler to perform. Undoubtedly the period of protection given by crutching will be greater among those sheep which have been operated on than those which have not been treated. Jetting is also more effective and easier to perform on "Mulesed" sheep. The poison can reach the area required quicker and more effectively when the breech wrinkle and loose skin are removed. In addition the wrinkle and loose skin by their moisture holding characteristics

are retaining urine and by so doing are to some extent washing out and neutralising the effects of the poison. In addition the Mules operation not only greatly reduces strike, but also reduces blowfly population, because in attacking the breech of the living sheep we are attacking the *natural* and most favourable breeding ground of the primary fly, who is the arch enemy that initiates strike.

Experiments have proved that the "long" tail alone can reduce the incidence of breech and tail strike in ewes to less than half of that in animals with short tails. In the case of the wrinkled tail this can be protected by cutting to a length of about four inches when tailing as a lamb. By tailing in this way we get below the wrinkled portion of the tail and so leave a clean end instead of one with little pockets and rivers. There is also some brushing effect with the longer tail. The use of the longer tail is as above described, plus the important fact that the tail presses the wool away from the centre of the breech and, by doing so, allows for a freer drainage. Where crutching is left until the stage when many dags have formed, complaints will be made that the longer tail has the effect of increasing dags, but if crutching can be attended to at the appropriate time, and the end of the tail is properly cleaned of wool there no longer remains any doubt of the protection conferred by the longer tail. It is possible that the brushing effect referred to above can and does reduce the dag quantity in a lush season. It has been observed that the brushing effect of the longer tail does continually remove a proportion of the dung. After excretion it is obvious that a short tailed sheep is helpless in this respect. While agreeing that the long tail has the effect of making shearing and crutching slightly more difficult it is obvious that we must be prepared to give something away on some point. When giving the "long" tail it is important to leave a long skin flap underneath on the bare area with a shorter cut on the woolly surface. Tailing in this manner results in a clean bare end instead of an end carrying a tuft of wool. It is important that the "long" tail be shorn efficiently because if a tuft of wool is left on the tail, the protection can quite easily be lost.

It is suggested that tail strike can be reduced by "Mulesing" the tail. By removing a strip of skin from the tip to the butt on the top of the tail it is possible that the skin contraction will cause the bare area underneath the tail to be extended and stretched to the maximum resulting in an increase of the total area of the bare area in addition to flattening out and removing tail wrinkles. Undoubtedly the long tail also gives added protection against strike to sheep that are "plain" and not very susceptible. Quite apart from reducing crutch strike (which is undoubted) the "long" tail reduces tail wound strike owing to the smaller wound and quicker healing, resultant upon docking the tail further away from the butt. More flesh exists nearer the butt and the larger the wound the slower the healing. Although not as important as for ewes, it is considered that the "long" tail can also be given to wethers with advantage. Under station conditions at least, where many lambs are being marked quickly, confusion and faulty docking can occur when tails are being cut to two lengths. This factor is eliminated when both ewe and wether lambs are given the "long" tail. In addition to this it is possible when a wrinkly tailed wether is docked short, that the contraction of skin will cause the tail wrinkles to "pucker up" and form "pockets" suitable for strike. When docking, it is necessary to think not so much in terms of the length of the tail as of a sheep that at maturity will possess a tail that covers and is just longer than the tip of the vulva. Discretion is necessary when tailing as it is obvious that a young lamb given a tail of a measured length of four inches will have a tail longer than four inches when fully grown. Excessive burr and seed can transform a tail that is too long into a fly trap inasmuch as the seed and burr matts the wool on the end of the tail causing it to hold moisture and can lock the tail to the crutch area with resultant staining and tail strike.

Very high protection is given by the Mules operation and "long" tail, but it is limited to some extent by the increase in the length of the wool as time goes on. In view of this it is still very necessary to crutch and/or jet the sheep. *No reliance must be placed on any one measure of protection.* If possible all the measures should be adopted particularly during periods of "fly" waves. Provided it is possible to muster and handle the sheep, Mulesing, "long" tail, crutching and *thorough jetting when there is a bad fly wave* will eliminate fly trouble and pay handsome dividends for the expense and labour involved. Under pastoral conditions blowflies are bad only in good seasons, and in good seasons it should be possible to concentrate the sheep and in this manner overcome largely the mustering difficulties. Generally sheep are easier to muster in good seasons. They run in bigger mobs and are not so scattered as in poor seasons.

This concentration of sheep brings up another interesting point. It is advisable to brand or mark the more developed ewes at shearing time and when convenient, draft and place them in a convenient paddock or paddocks where they can be more easily handled and more often inspected and treated for "strike" in the event of blowfly activity. If this is done it is then possible to *do* something in the case of sheep which have not been made insusceptible by the Mules treatment in respect to selective breeding as a permanent method of reducing fly strike, *whilst still retaining desirable fleece characteristics.* In short, extremes are discouraged and the flock is kept "in the middle of the road" in respect to development by mating the plainest of the rams with the more developed ewes and the more developed rams with the plainest ewes. It is very desirable to keep more developed rams from joining with the more developed ewes. *From a wool production point of view* it is equally desirable to keep the lightest and plainest of the rams away from the lightest and plainest ewes.

Mating unlike individuals *of the same blood* (not cross breeding) is a powerful tool for *immediately* producing uniformity within a flock. In other words the aim is to achieve a larger mean of progeny that are relatively not predisposed to strike owing to their improved breech conformation.

The Apple Leafhopper.

(*Typhlocyba froggatti*, Baker.)

C. F. H. JENKINS, Government Entomologist.

The Apple Leafhopper, Apple Jassid or Canary Fly, is a native of Europe which has now become established in many of the apple growing countries of the world. It was first recorded doing damage in Australia in 1918, when orchards in New South Wales became infested. Since that time the insect has spread gradually to all the Eastern States, reaching Queensland as recently as 1938. Until very recently Western Australia was considered to be free of this pest, but in 1942 typical leafhopper injury was detected in the Bridgetown district, and insects collected were subsequently identified as true apple jassids.

DESCRIPTION.

The adult leafhopper is a small, slender winged insect measuring about ⅛ of an inch in length. Its general colour is usually yellowish green. The eyes are dark and prominent. The forewings are long and narrow and relatively thickened so as to form a protection for the almost transparent filmy and broader hind wings which are not visible when the insect is at rest.

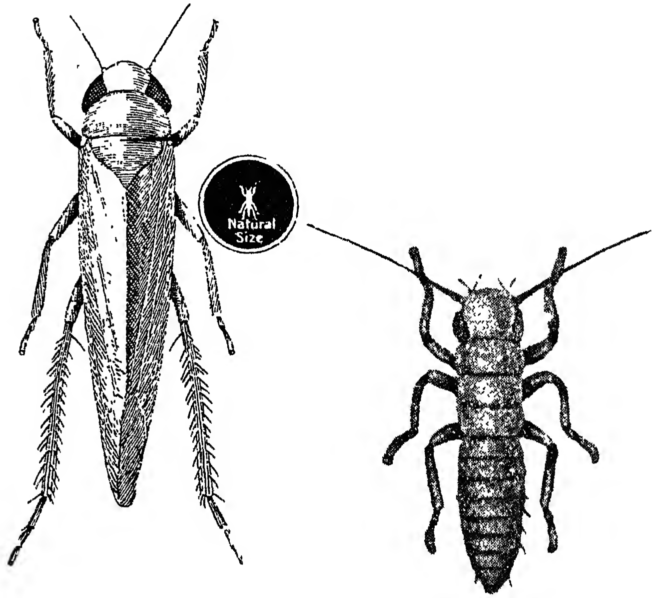

Fig. I.
The Apple Leaf-hopper. Left, adult; right, nymph.
[After Noble.]

The immature stages or nymphs are pale greenish-yellow in colour and vary in size from the minute newly-hatched individuals to the nearly full-grown nymphs which approach their parents in size. As will be seen from the illustration the nymphs have the same general form as the adults, but lack fully developed wings.

LIFE HISTORY AND HABITS.

Some details of the insect life history under local conditions have still to be worked out. As in the Eastern States, however, two generations per annum are the rule.

The spring generation emerges from over-wintering eggs which have been deposited by the previous season's females in the young bark tissues of the apple trees. Emergence may be expected under local conditions to commence about October, and to continue for several weeks. The time required to reach maturity is about six weeks and then the summer eggs are deposited in slits in mid-ribs and stalks or petioles of the leaves. The female leafhopper is provided with a horny sword-shaped ovipositor or egg-laying tube which enables her to penetrate easily the leaf tissues and the fresh season's wood in which the eggs are deposited. The situations where over-wintering eggs are laid may be recognised by what appears to be a slight blistering of the bark. These marks should not be confused with the lenticels or breathing pores of the bark, however, and a hand lens is really necessary to identify the swellings with certainty.

Although quite an active insect the apple jassid does not often fly far, and is usually only seen flitting from leaf to leaf when it has been suddenly disturbed.

TYPE OF INJURY.

In the Eastern States the leafhopper is not ranked with either the codlin moth or the fruit fly in economic importance, because it is not so destructive to fruit crops and is more easily controlled.

The leaf injury caused by the feeding of the pest is manifested by the formation of pale blotches on the leaves and a general yellowing of the foliage. In the case of heavy infestations injury may be so bad as to cause a certain amount of leaf fall. The discolouration of the leaves will naturally affect their normal functioning and may induce the formation of weak buds and so affect the next season's crop.

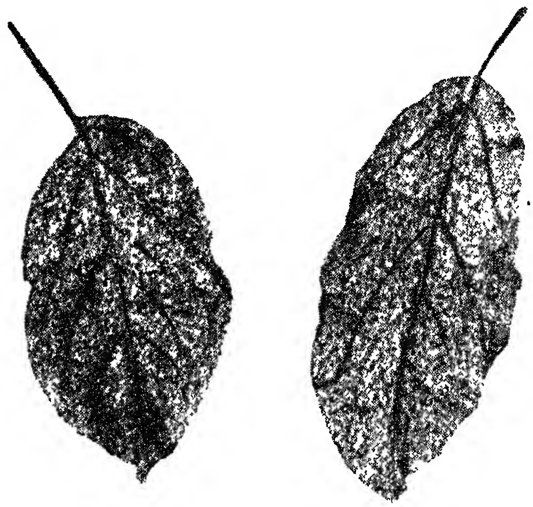

Fig. II.
Showing leaf-hopper injury to apple leaves.
[Jour. Agric., Vic.]

In addition to disfiguring the leaves, fruit may be blemished not only by the feeding marks but also by the excreta deposited by the numerous insects. The tiny specks accumulate on the fruit and especially if damped with dew or rain may cause sticky smears which require special treatment before the fruit can be marketed.

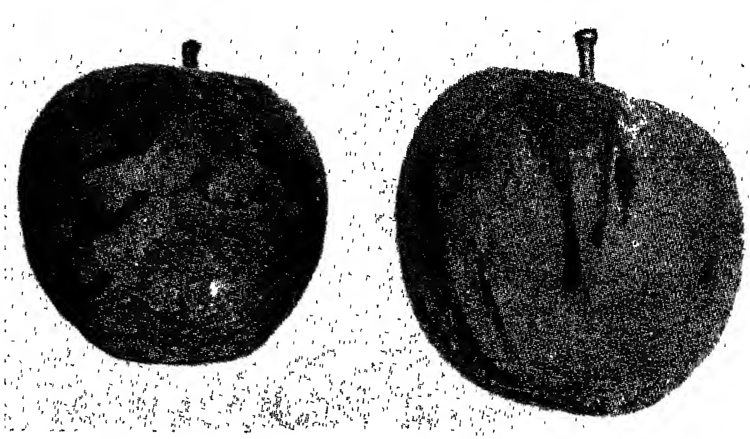

Fig. III.
Blemishes on apples caused by jassid excrement after being affected by water.
[Jour. Agric., Vic.]

Since with most species of jassids the population is greatest towards the end of the season, late varieties of apples are likely to be the most seriously affected.

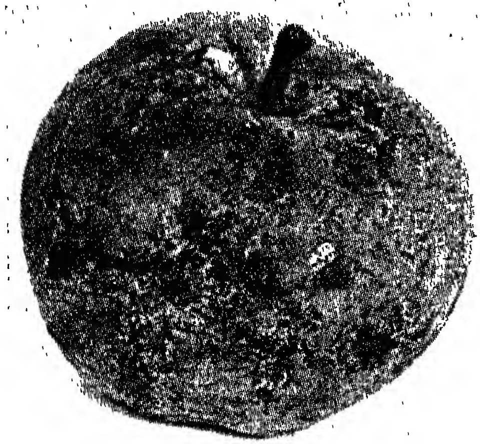

Fig. IV.
Spotting caused by jassid excrement.
[Jour. Agric., Vic.]

METHOD OF DISPERSAL.

Being a winged insect dispersal from tree to tree is easily explained, but extensive flights are not habitually made. Although it is impossible to state definitely by what means the insect gained access to Western Australia, imported nursery stock is the most likely medium for its introduction. It will be remembered that over-wintering eggs are deposited in the bark tissues of the apple tree, and such eggs could easily escape detection on young apple stocks.

HOST PLANTS.

The principal host plant of this pest, as its name implies, is the apple. Pears and other fruit trees growing in infested apple orchards in the Eastern States have been observed to suffer only slight injury. In addition, the insect has been observed feeding on blackberries, hawthorn and other plants, but it is doubtful whether breeding takes place on other than apple trees.

It is worthy of note that several species of leafhoppers are very common on weeds and blackberries in many of the apple growing districts. Considerable concern on this account has been expressed by growers, but as the common blackberry and weed haunting varieties are of little economic importance and quite distinct from the apple jassid, they may be safely ignored.

CONTROL.

On account of the protected situation in which the over-wintering eggs are deposited, dormant sprays are of little use in controlling this pest. Eastern States experience has shown, however, that the following formulae applied in the summer give satisfactory results, and local experiments have borne out these findings.

1. Nicotine sulphate or Black Leaf 40, 1 pint; soap, 2 lb.; water, 80 gallons.

2. Nicotine sulphate or Black Leaf 40, 1 pint; white spraying oil, 1 gallon; water, 80 gallons.

Encouraging results were also obtained in New South Wales from the use of the following:—

Lime sulphur, 1 gallon; nicotine sulphate, ⅜ pint; water, 35 gallons.

When the nicotine sulphate is not available white oil 1 : 80 may be used alone, but is inferior to the first two formulae cited.

Kerosene Emulsion.

If for any reason proprietary insecticides are difficult to obtain, a useful contact spray for many orchard pests will be found in kerosene emulsion, which may be prepared as follows:—Boil ½ lb. of soap in a gallon of water. Add slowly two gallons of kerosene and churn violently. For use as a spray this stock solution may be broken down to one part of stock to 10 parts of water (warm if possible). Care should be taken to violently agitate the soap solution when the kerosene is being poured in, to ensure a good emulsion, otherwise some of the kerosene will remain in a free condition on the top.

In carrying out any treatments it should be remembered that the insects feed on the under sides of the leaves. The sprays depend almost entirely upon contact for their efficiency, and therefore must be applied with sufficient force and in such a manner as to thoroughly wet the foliage.

Time to Spray.

For the most satisfactory control the first spray should be applied when the majority of overwintering eggs have hatched, but before the insects have reached maturity and are themselves ready to lay. It is not possible to state the exact time of application as this will vary with seasonal and local conditions, but the end of October may be taken as a guiding date.

A second treatment three weeks after the first is necessary to deal with later hatchings, as eggs are little affected by insecticides. It is essential that the first brood be successfully controlled if damage is to be reduced to a minimum, and as the immature stages are much more easily killed than the adults the correct timing of the spray is important.

Combined Spray.

It is customary with many apple growers to apply, about November of each year, a spray consisting of arsenate of lead and white oil for the control of looper caterpillars, apple curculio, and Bryobia mite.

As already stated the exact hatching time of the apple jassid cannot be definitely forecast, but it may be assumed that nymphs will be present in November or earlier and nicotine sulphate added to the usual white oil-arsenate of lead spray will save the labour involved in a separate treatment.

The formula recommended for a general purpose spray is as follows:—

White oil, 1 gallon; arsenate of lead powder, 5 lb. or arsenate of lead paste, 10 lb.; nicotine sulphate, 1 pint; water, 80 gallons.

BIOLOGICAL CONTROL.

A tiny wasp parasite (*Anagrus armatus* Ashm.) which attacks the eggs of the jassid was introduced into Tasmania from New Zealand in 1935, and through the co-operation of Dr. J. W. Evans of the Tasmanian Department of Agriculture a consignment of wasps has been received in Western Australia for liberation in infested orchards.

Although the parasite will not eradicate the pest it is hoped that it will exercise a controlling influence and at least reduce the amount of spraying which might otherwise be necessary to keep the pest in check.

IMPORTANT.

Since the apple jassid is not as yet widely distributed in Western Australia all apple growers are advised to keep a constant watch for the pest and to forward for identification any insects of which they may be suspicious.

The most heavily infested orchards are in the Bridgetown district and as may be expected some Balingup and Donnybrook properties are also affected.

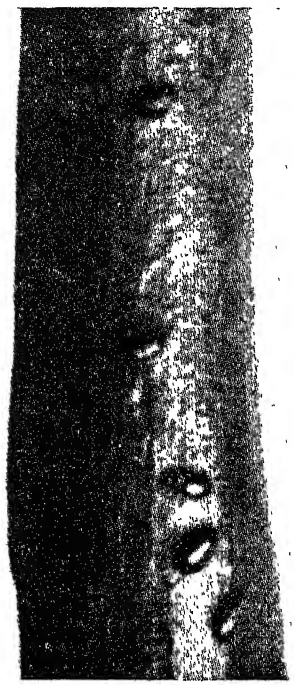

Fig. V.
Swellings in bark of apple twigs indicating the presence of winter eggs of jassids.
[Jour. Agric., Vic.]

Orchardists in clean districts should take great care when procuring young trees or scions to ensure that material is obtained from clean orchards. This applies also when obtaining parasites for woolly aphis control. Cuttings carrying parasitised aphis should only be secured from clean orchards, otherwise leafhopper eggs may be carried in the twigs.

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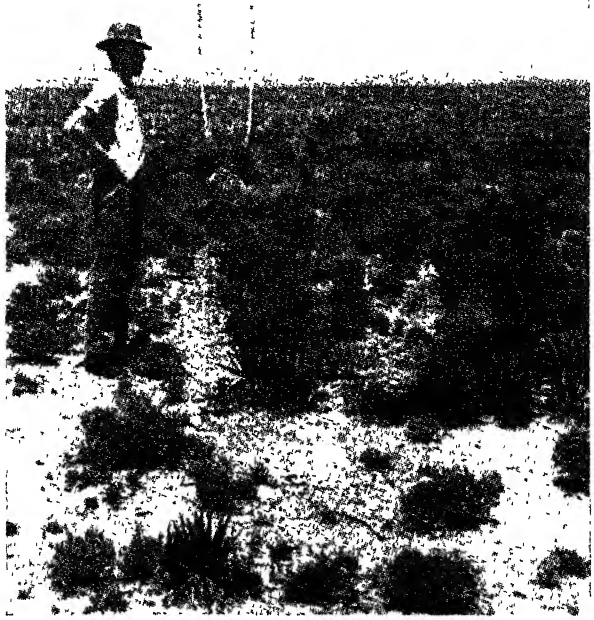
Rubber Production in Relation to Western Australia.

A. J. MILLINGTON.

Rubber has become an essential material for both the peace and war-time economy of mechanised nations. The pre-Japanese war principal source of natural rubber was the Malay Peninsula and Archipelago which yielded 90 per cent. of the world output. Although huge stocks of rubber had been stored by Britain and America, they were obviously insufficient to meet the war requirements of the United Nations and as was the case with Germany in 1915, recourse was made to alternative sources. Minor supplies of natural rubber to the United States prior to Pearl Harbour were derived from the Amazon valley (Brazil) and Mexico (Guayule rubber) whilst synthetic rubber production amounted to 12,000 tons per annum. Energetic steps were taken by the United States Government to expand the flow of rubber from all three sources and of the 600,000 tons required for 1943, 250,000 tons will come from synthetics, which have proved by far the best source of war-time rubber. During 1944, the United States will attain a production rate of 850,000 tons of synthetic rubber per annum.



Wild guayule shrub, mixed with other plants on a ranch in Texas. The small bushy plants are guayule.

However, just as the butter industry has continued to flourish, despite the competition of a synthetic (margarine), which can be produced much more cheaply, so natural rubber is generally considered to have a place in the post war economy. Although Australia has about 15,000 acres of rubber plantation in Papua and New Guinea the yield from this area is an insignificant portion of our rubber requirements which were about 15,000 tons per annum prior to the war. Should it be deemed advisable for Australia to become wholly or partly self-sufficient in

respect to rubber production after the war, the three most promising alternatives would be plantation rubber from the tropical tree *Hevea Brasiliensis*, synthetics and Guayule.

Although the best rubber in the world still comes from the wild *Hevea Brasiliensis* of the Amazon basin, the Malayan plantations of this tree provided the greatest and cheapest source of pre-war rubber. This was achieved, however, only on the basis of a plentiful supply of cheap labour. The average output per plantation worker is one ton of rubber per annum. This is equivalent to about 40 lbs. per week so that at sixpence per lb. the worker would earn only twenty shillings. Cheap rubber can therefore only be achieved by exploiting very low-priced labour. A profitable pre-war price for plantation rubber was about sixpence per pound (Australian currency).

Under cultivation the plant looks much different. These are five-year-old cultivated plants in California.

Australia should emerge from the war with a fairly well developed chemical industry, technologically capable of producing synthetic rubber. A number of types of synthetic "rubber" material have been developed for special purposes, but the most famous is the general purpose Buna-S. This material is derived from the combination, under suitable conditions of temperature and pressure of two chemicals, butadiene and styrene. The butadiene constituent is made from either petroleum by-products or the ordinary beverage alcohol (ethyl). The cost of butadiene from alcohol is in America at least ten times that of the same material made from petroleum. The disparity in these costs is of importance to Australians since for self-sufficiency reasons, alcohol from our wheat and sugar would be preferable as a source of butadiene. The other constituent of synthetic rubber, styrene is derived from coal tar.

The average cost of the synthetic rubber now being produced in America is given as about 2s. 6d. per pound in Australian currency. Estimates of the post-war cost vary from sixpence to two shillings per pound (Australian).

For automobile tyres the efficiency of the synthetic is about 90 per cent. of the natural product, but for special purposes such as petrol pipes it is more efficient. It is usual for most purposes to mix a considerable proportion of natural rubber with the synthetic. The Germans for instance, by report, use 65 per cent. natural rubber to 35 per cent. synthetic. One effect of the synthetic rubber programme is that the United States is rapidly drinking itself "dry." The new alcohol is going into butadiene instead of beverage spirits such as whisky.

It is unlikely that Western Australia would figure as a source of either plantation rubber or synthetics and participation in any production programme would follow only on Guayule cultivation. The increasing efficiency of our rural industries as measured in terms of output per producer makes the expansion or even the maintenance of a substantial rural population increasingly difficult. Diversification of farming, particularly in those areas where wheat is now the principal crop, appears to be a possible solution to this problem. Little is known of the volume and price levels of the normal Western Australian agricultural exports to the post-war world, but it is likely that despite the expansion of synthetic rubber production there will be no great surplus of this commodity. The applications of rubber were increasing rapidly before the war and small increments in consumption per capita would absorb the current production of both natural and synthetic products.

TABLE I.

Country.	Pre-war consumption of rubber per 100 population.
China	3 lbs.
Russia	30 lbs.
Australia	500 lbs.
United States of America	1,000 lbs.

The Mexican rubber shrub Guayule (*Parthenium argentatum*) is a desert plant found naturally on the fans of wash material, which form at the mouth of steep mountain gullies. The area is a high plateau, from 3,000 to 7,000 feet above sea level, from which arise hills of varying size and height separated by plain-like valleys. The rainfall amounts to 7-15 inches per year and 90 per cent. of it falls during the warm months equivalent to December-April in Australia. Owing to the high elevation, temperatures vary from hot in the daytime to very cold at night and in its native habitat Guayule occurs on stony permeable soils, never on heavy clay soils.

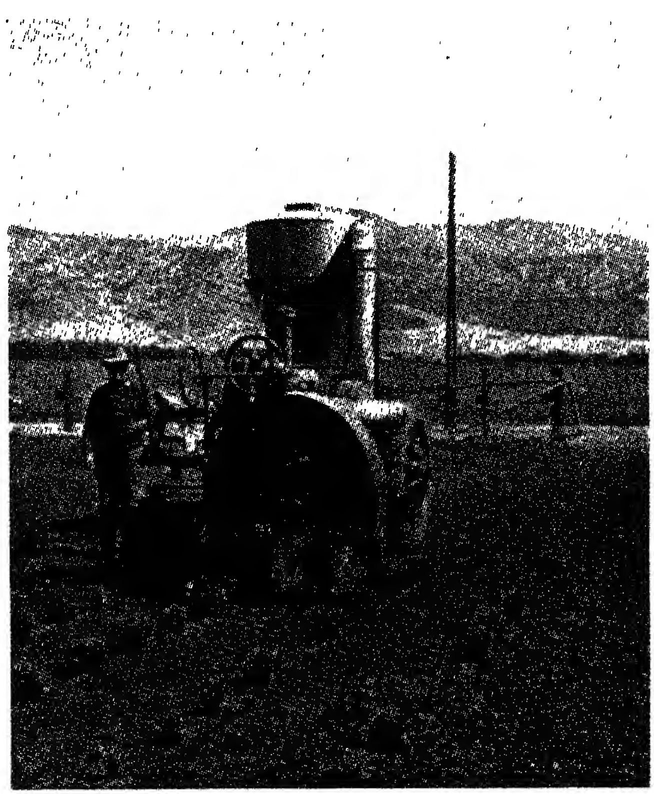
The exploitation of Guayule as a rubber source extends over the last 40 years and since 1912 it has been raised as a domesticated plant at Salinas in California. The rubber is secreted in the stems and roots, so that harvesting necessitates destroying the plant. It is quite equal to Malayan rubber and may be used without admixture.

The Salinas climate in California is somewhat similar to that of the Western Australian wheat belt with a rainfall of 14 inches which falls during the winter months. This climate has proved satisfactory for Guayule plantations established from seedlings and was the chief research area for this crop.

Prior to Pearl Harbour 500 acres of dry land were under Guayule at Salinas. To meet the war-time demand for rubber some 50,000 acres of irrigation land have now been sown down and are expected to yield 20,000 tons of rubber by the end of 1944. Fairly large plantings have also been made in South Australia where one block of 83 acres has been sown under irrigation.

Because of the shortage of vegetables no further plantings on irrigation land are to be made in America. With the success of the synthetic rubber programme the shortage of vegetables is more acute than that of rubber.

The plants are raised in nursery beds and the seedlings transplanted when they are four to five months old. Machinery for reducing the labour requirement for these operations is in use in America where with the requisite planter a team of five men plant about one acre per hour. The plantations are inter-row cultivated to control weeds and are usually harvested, under dry land conditions, when they are four to six years old, giving yields of 1,000 to 1,800 lbs. rubber per acre. Under irrigation, growth is more rapid and the yields obtained are higher.



The seed harvesting machine works like a vacuum cleaner and is driven by a tractor.

Experiments with Guayule in Western Australia date from 1929 when a few plants were raised at the Hamel State Nursery and transplanted at Merredin Research Station and Muresk Agricultural College. At Merredin, plants survived for up to three years and attained a height of 18 inches. One of the original shrubs is still thriving at the Muresk College where it has attained a height of about 3 ft. 6 in.

In November, 1942, several pounds of seed of Guayule were received from the Council for Scientific and Industrial Research, but failed to germinate. Particulars were later received from America of the chemical treatment necessary to ensure the germination of fresh seed. Table II. gives the results of various treatments with sodium hypochlorite after pre-soaking for 20 hours.

TABLE II.

Length of Treatment.	Concentration of Hypochlorite.	Germination.
6 hours.	Water only (Control)	3%
6 „	2%	22%
6 „	4%	37%

Twenty ounces of treated seed were sown in a 100 sq. ft. nursery bed at Merredin on February 1st, 1943. About 10,000 plants were obtained from this bed, sufficient for an acre of plantation. These plants made rapid growth under irrigation and were six inches high and flowering by early April.

Later plantings at both the Merredin Research Station and the Hamel State Nursery did not give such satisfactory results. This may have been due either to lower temperatures or the reduced hours of daylight.

During early June the seedlings were transplanted to the indicator trials located at Merredin, Wongan Hills, Chapman (Geraldton), Beverley and Salmon Gums Research Stations, and also to experimental plots at Scaddan, Wyalkatchem and Kellerberrin.. In these plantations the shrubs were spaced at intervals of two feet equivalent to approximately 10,000 plants per acre.

Direct sowing of the seed on the plantation site would avoid the considerable labour and expense of raising and transplanting seedlings. To obtain adequate weed control this operation can be attempted only in late autumn or winter months. Although germination was obtained from field plantings during July, 1943, in the metropolitan area and at the Avondale Research Station, the young seedlings were killed by frost. There are, however, extensive areas in the northern agricultural districts where, as frosts are not usually experienced it should be possible to establish plantations of the shrub direct from seed.

Although no reliable forecast of the economics of Guayule cultivation can be made at this juncture yields of 1,500 lbs. rubber to the acre appear to be a reasonable expectation from five to six year old plantations. At six or more pence per pound such yields should be profitable, particularly if direct sowing methods can be used. A normal farm machinery could then be used for most of the cultural operations. The rainfall incidence in the area of Mexico where Guayule occurs naturally is very similar to that of the Kimberleys in Western Australia. Trials are, therefore, being conducted at the Ord River Experimental Farm to obtain data from this area. The temperatures in northern Western Australia are, however, much higher due to the lower elevation.

A drought period each year is apparently necessary before the Guayule secretes notable quantities of rubber. An annual growing period of about five months is generally considered adequate for Guayule.

Acknowledgment is gratefully made to the Deputy Conservator of Forests, Mr. Stoate and Mr. Ross of the Hamel State Nursery and to the managers of the Research Stations and Mr. E. Langfield, for their assistance with this investigation.

The Growing of Maize for Grain.

H. G. ELLIOTT, Agrostologist.

Climate.

Maize being indigenous to the warmer parts of either Southern Mexico, Central America or Northern South America, thrives best under warm moist conditions. It is susceptible to frosts and must be grown in regions which are free from them during the growing season. The plant is fairly drought resistant, providing the ground is in good condition and well cultivated between the plants until the tasselling period. Ample evidence has been obtained in this State to show that maize can be grown successfully for both green feed and grain in the south and west coastal and irrigation areas.

Soil.

Maize can be grown on a variety of soils, but is best suited to a deep sandy loam containing ample organic matter.

For the production of grain the critical period is the tasselling stage, and warm weather with ample soil moisture at this time is essential for heavy grain crops. These conditions can be assured by irrigation or by growing the crop on "summer moist" land.

Preparation of Seed Bed.

As maize is a deep rooter the soil should be ploughed to at least six inches for preference with a mouldboard plough which will bury all green material and trash which may occur on the surface. This ploughing should be done in the early spring so as to give the soil opportunities to mellow. The final preparation consists in obtaining a surface layer of some two inches of reasonably fine soil in which to plant the crop. It is necessary to compact the seed bed, and this is best done by double discing and harrowing, and if necessary, the use of a roller followed by a further harrowing.

Time to Plant.

Maize should be planted late enough to escape frost in the spring and early enough to miss the frosts in the autumn. October to December will be found the most suitable planting months.

Varieties.

The white seeded variety, Hickory King, is the most favoured for green feed and seed production in this State. However, small quantities of "90 Day" and Red Hogan are grown for early green feed.

Seed Selection.

For future crops farmers should select their own seed, not by picking likely looking cobs from the crib at the time of shelling, which will give fair results if conscientiously carried out, but by selecting cobs in the field, by paying attention to the type of plants and types and number of cobs produced per plant. Healthy vigorous plants with cobs that have a pronounced drooping tendency is desired. If, when mature, the cob is pointing towards the ground there will be little or no damage from water gaining access to the grain, if rains fall prior to harvesting.

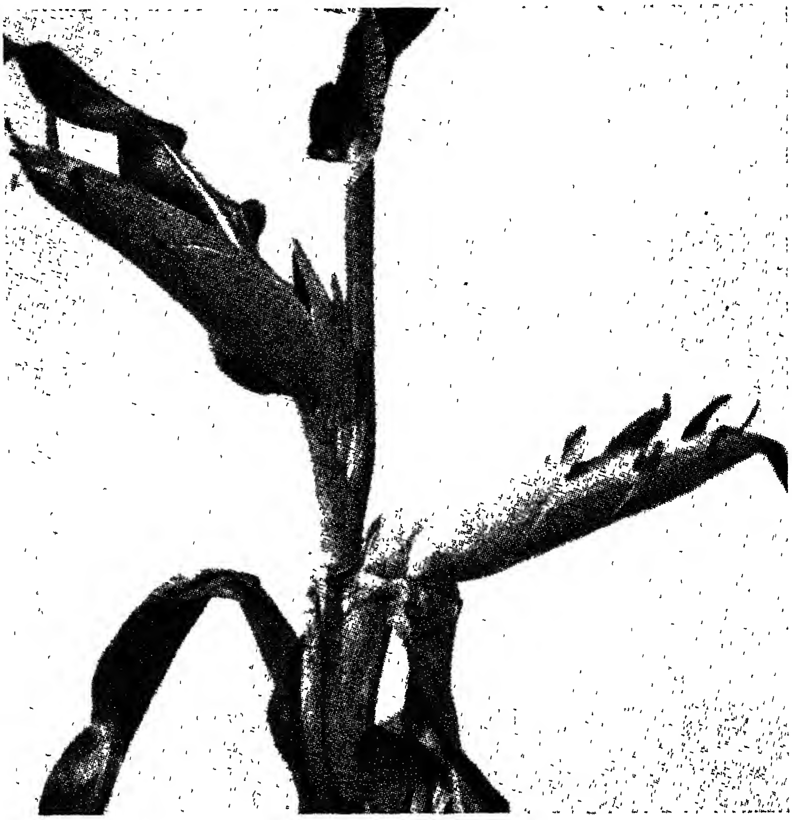


Fig. 1.
Typical stalk of a prolific variety of maize showing two good ears well balanced on the stalk.
[Photo M. T. Jenkins, U.S.D.A.]

Rate of Seeding.

Maize for grain is either planted in "drills" or "hills." In this State the former method is recommended. The seed is sown in drills about 3 ft. apart with about 12 inches between seeds if under good moist conditions. With drier conditions the rows should be four feet apart with 16 inches between plants. Eight to 10 lb. of seed would be sufficient to sow an acre.

Depth of Planting.

Two or three inches deep is considered the best depth to sow, but the seed can be sown to four or five inches deep if necessary to ensure them being placed into moist soil.

Fertiliser.

It is normally recommended to use at least 3 cwts. of potato manure per acre, the fertiliser being sown in drills, but not in direct contact with the seed if this can be avoided, but owing to the present fertiliser restriction, the grower can only obtain an allowance of 2 cwt. of superphosphate and 1 cwt. of nitrate of soda per acre for this crop. Consequently, any farmer desiring to grow maize for grain would order that fertiliser which is allowed.

Method of Planting.

Single and double row maize machines for planting can be obtained. These machines are designed to sow the grain at regular intervals and are fitted with an attachment for applying the fertiliser. The machines open the furrows, drop the seed, cover, and press them into the soil in one operation.

When planting under irrigated conditions it is recommended to sow rows about four feet apart and run an irrigation furrow in between every double row.

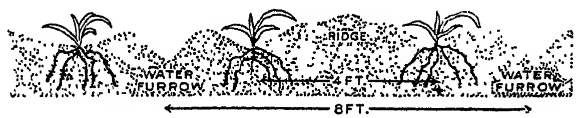


Fig. 2.
Diagram showing a method for planting maize
[By courtesy F. D. Richey, U.S D.A.]

After Planting Cultivation.

This is essential for control of weeds and to increase soil aeration. The cultivation should begin soon after seed sowing and continue, if necessary, until the plants reach five to six feet high. Single or two row cultivators are recommended. The depth of cultivation should not exceed two to three inches or injury to the roots is likely to occur. Two to four cultivations should be sufficient during the growing season.

Fig. 3.
Widely spaced maize rows with cow peas growing between the rows.
[Photo F. D. Richie, U.S.D.A.]

General.

Some farmers practise the method of following on a potato field with maize and occasionally pumpkins. After the potatoes have been lifted the ground is thoroughly cultivated and packed and the maize seed sown as explained in the foregoing information. If, however, pumpkins, or a leguminous crop is grown in association, the maize is spaced at six to eight feet between rows and the other crop interrowed. Fertiliser is not usually applied, as it is considered that ample is present from the prior potato crop. It is recommended, however, that a small application of potato manure be applied at the time of planting.

Harvesting.

For grain the most common practice is to allow the crop to stand in the field until the grain is quite ripe, a condition which is shown by the husks becoming dry and hanging down. The cobs are then gathered by hand and husked in the field or in a shed.

The grain in the husks should be quite dry before storing, otherwise it is likely to heat and mould. Until thoroughly dry the cobs can be stored only in open sheds with free air circulation.

Husking and shelling can be carried out in the winter months and shelling is done best by using a maize shelling machine, which can be operated by hand or power. The grain is then graded, if necessary, and bagged for sale. It is sold in the bushel, which means 56 lb. weight. It has been estimated that about 75 lb. weight of "ears" will produce about one bushel of grain.

The "core" although of low feeding value can be ground and used as a meal.

The stalks and leaves "stover" which is left after the "ears" have been removed, contain about 1-3rd of the total food produced by the plant, and can be used, if harvested, and chaffed or shredded for feeding to horses or cattle for maintenance food during the winter.

The modern practice is to cut the crop after the grain has commenced to colour and dent, and tie the bundles, stook until the grain is dry and the stalks cured, which takes approximately five to six weeks. The cobs are then removed and the fodder stored away until required.

Notes on the Treatment of Mastitis in Dairy Herds.

In the control of mastitis, particular attention must be given to the application of measures designed to prevent the spread of infection, from animal to animal. The more rigorously these preventive measures can be applied the fewer will be the number of cases of the disease that are likely to occur. Since, however, our knowledge of the disease is still incomplete, no matter how thoroughly and energetically preventive measures are applied it will not be possible to entirely prevent the spread of infection, and new cases will, from time to time make their appearance, and must receive prompt attention.

Treatment, whatever promise it may offer must, however, be regarded as a supplementary measure. Prevention must remain the primary consideration.

The form of treatment, which in the past has generally been relied upon, has consisted of the frequent and thorough stripping out of affected quarters, together with fomentation with hot water, and massage with various stimulating liniments.

Beneficial results are frequently obtained from treatment of this kind. These results, however, are often more apparent than real, for although the signs of inflammation may subside, and the milk regain its normal appearance, the infection may persist in the quarter. This is particularly the case with chronic streptococcic mastitis, wherein the infection once it has become well established usually persists throughout the life of the animal, often to flare up periodically, and always to inflict irreparable damage, slowly but surely impairing the function of the quarter, reducing the milk yield, and finally causing it to dry up completely.

It is obvious then, that any form of treatment, in order to effect a permanent cure must succeed in destroying the infection within the udder itself. The means whereby it has been sought to bring this result about have broadly consisted of (a) the administration of drugs by the mouth, which during their excretion through the milk will destroy the infection in the udder; (b) the injection of bactericidal solutions or suspensions into the udder through the teat duct, which will come into direct contact with the organisms causing their destruction.

Of the drugs given by mouth, high hopes were held for sulphanilamide, which has given outstanding results in the treatment of certain human infections. The results obtained, however, were in the main disappointing, and since the treatment is costly it cannot generally be recommended. Amongst the solutions injected into the udder through the teat duct, the best known are the acridine derivitives, acriflavine and entozon. Both have given good results in the treatment of the less advanced cases of chronic streptococcic mastitis. Amongst other substances, for which excellent results have been claimed in the treatment of this type of mastitis, may be mentioned colloidal silver oxide, and tyrothricin, an extract prepared from a soil bacterium.

Sulphanilamide in Mineral Oil.

Quite recently a treatment, which from the view point of efficiency and simplicity of application appears to surpass all others previously employed has been described from the United States. It consists of the injection into the affected quarter of a suspension of sulphanilamide in mineral oil. The preparation of the mixture presents some difficulties, and in order to obtain a stable suspension it has to be passed through a homogenizer. Homogenized sulphanilamide-in-oil is now being prepared in this State, and may be obtained from wholesale chemists.

Highly satisfactory results have been reported in the treatment of both acute and chronic mastitis. The drug is non-irritant to the udder tissues, causing neither swelling nor pain. There is no alteration in the milk secreted, and no reduction in the milk yield. Both lactating and dry cows may be treated.

A dosage of 40 c.c. of sulphanilamide-in-oil should be injected into quarters of average size, but this may be increased to 50 c.c. if the udder is very large. This treatment should be repeated on four consecutive days, and should be carried out immediately after the morning or afternoon milking (whichever is the more convenient) after the quarter has been completely stripped out. The mixture is allowed to remain in the udder, and will be found to have been completely absorbed by the next milking. If a satisfactory response is not obtained a second course of treatment will be necessary, increasing the dosage to 80 c.c. and repeating the injections on four consecutive days.

The published reports indicate that about 70 per cent. of cases may be expected to respond to the initial course of treatment; others will require two or more courses of treatment before a cure is effected. The injections may be made by means of a teat tube attached to a syringe capable of delivering the required

amount of the suspension. The udder and teats should be thoroughly washed with an antiseptic solution, and the teat orifice swabbed with methylated spirits, before the teat tube is inserted. The teat tube and syringe should be sterilised by boiling before use.

It is scarcely to be expected that the same high degree of efficiency obtained in experimental herds will be maintained in the more severe and old standing cases encountered on commercial dairy farms. The treatment, however, is worthy of a thorough trial, and those dairy farmers desiring to employ it should consult their nearest veterinary officer. The extent to which this treatment is likely to be applied will doubtless be limited by its cost. Based on present prices the cost of the initial course of treatment is about 5s. per quarter, and for the second and subsequent courses of treatment 10s. per quarter.

Steps to Prevent or Control the Spread of Mastitis.*

There is still much to learn about mastitis in dairy cows. Attempts have been made to eliminate the infection from some herds, and in a proportion of cases these have been more or less successful. Even though our knowledge is incomplete, much more can be done to keep the occurrence of the disease down to a minimum.

In the following article are set out some of the more simple, straight-forward facts that should guide dairy farmers in their attempts to control the spread of mastitis in their herds.

The commonest form of the disease is the so-called chronic mastitis. This is due to the mastitis streptococcus, *Streptococcus agalactiae.*

Another common form, which appears to be most severe in young cows, is due to a staphylococcus, very much the same type of germ that causes boils in human beings.

Other forms, in which there is a very acute inflammation in the udder with general distress, are seen less commonly, but sometimes they may spread rapidly to the majority of the cows in a herd. These may be due to other types of streptococci or to types of bacteria found in the bowel.

CONTROL VARIES WITH TYPE OF MASTITIS.

One type of mastitis may possibly be controlled by some special method, but this method may be useless for the control of other types. This leads to confusion in the minds of dairy farmers and sometimes of control officers, especially if laboratory aid in diagnosis is not available.

Recent work shows that the bacteria which commonly cause mastitis may be carried by cows which have not developed any sign of disease. These bacteria may also be present in sheds, on utensils and possibly in yards and camping grounds. In other words, the environment may hold these bacteria, which may have a chance of entering the udder at any time, but especially during milking operations.

The majority of workers believe that the bacteria enter the udder by growing up the teat canal and then progressing until they establish themselves in the milk sinuses. The evidence suggests that the infection of the teat canal takes place most commonly while the cow is in the milking shed. A small number of first-calf heifers become infected before they have ever entered the milking shed, but they form a small minority.

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* Reprinted by courtesy of the Mastitis Investigation Committee, C.S. & I.R.

PREVENT INFECTION OF TEAT CANAL.

If we concentrate, therefore, on preventing infection of the teat canal in the milking shed we should be able to prevent the most common form of infection and, further, the method should be just as effective against the mastitis streptococcus as against the staphylococcus or the other types of bacteria which can cause mastitis.

There is one additional important point to remember. A cow affected with mastitis is carrying more of the harmful bacteria than one that is not affected. It can increase the number of harmful bacteria in the environment and thus increase the chance of any other cow becoming infected.

EFFICIENT MILKING AN IMPORTANT FACTOR.

If the milk is withdrawn from the cow in the most efficient manner, mechanical injury to the udder is avoided, and time is saved which can be employed in doing essential things properly instead of in a slap-dash manner or not at all.

Every dairy farmer should try to understand the anatomy (the structure) of the udder and how milk is secreted and "let down." Only a brief mention of some of the essential features can be made here. Each quarter is a separate unit; there is no connection between the gland tissues of adjoining quarters. Each quarter is made up of the secreting tissue which may be compared in structure to a bunch of grapes. Each grape represents the cell in which the milk is formed. The milk then flows along the stalk or duct to a larger stalk or duct until the main stalks or ducts empty into the collecting cavity or milk cistern, which in turn leads into the teat canal. All this secreting and collecting tissue, or system, is supported by loose tissue containing blood vessels, nerves and fatty tissue and special muscle fibres, like those in the wall of the gut.

COW MUST "LET DOWN" MILK.

Milk is being formed or secreted all the time and gradually fills all the ducts and the milk cistern. At the end of the teat a strong muscle band keeps the teat canal closed and prevents the escape of the milk. The milk can be forced out through the canal by pressure. The pressure exerted on the teat, however, is not enough if the quarter is to be milked out quickly. Something must happen: the cow must "let down" the milk. This letting down of the milk is only an increase of the pressure within the quarter itself which forces the milk from the collecting ducts into the cistern. This increase of pressure is brought about by the contraction of the muscle fibres surrounding the cells and the ducts in the gland. What forces the muscle fibres to contract? This contraction is brought about by what is called reflex action. When the calf sucks or the milker starts to milk, the nerves in the tissues send messages to the brain which in turn sends messages to a special gland which throws into the blood stream a special substance which acts on the muscle fibres in the udder and causes them to contract and to force the milk down. This action occurs quickly and passes away almost as quickly.

CONDITIONS CONDUCIVE TO EFFICIENT MILKING.

Cows become used to being milked, and merely to bring them into the shed starts the complex mechanism which leads to the letting down of the milk. In order that this mechanism be used to the best advantage, and in order to carry out efficient milking, certain conditions must be observed and these are stated as follows:—

(a) There should be a rigid routine in the milking shed: so far as possible things should be done always in the same way and in the same order without undue delay.

(b) Especially there should be no delay in starting the milking after the udders have been washed or handled in any way. Don't wash the udders or handle them except immediately before starting to milk. Don't run down the line and wash the udders first and then go back to the beginning of the line and start the milking.

(c) The milking operation, whether by hand or by machine, should be as rapid as possible.

(d) The degree of vacuum at which the milking machine operates should be under efficient control. This is best provided by a weighted vacuum relief valve or by a spring loaded poppet type with covered spring. The machine should not be operated at a higher vacuum than that necessary to keep the teat cups on and 15 inches of vacuum is recommended as the maximum. This should not be exceeded.

If this routine is carefully followed the quarters will be rapidly and completely emptied and there will be no necessity to spend time in stripping.

After efficient milking there is no necessity to strip. The small amount of milk left in some quarters will be recovered at the next milking. If left in the quarter it will do no harm.

The physical violence of stripping, of unduly high vacuum, or of leaving the cups in position too long does harm, whereas leaving half a pound or more milk in the quarter does not.

CLEAN METHODS PREVENT INFECTION.

If we have efficient milking we have a sound basis on which to build a system to prevent bacterial infection of the udder in the milking shed. The sheds must be kept clean and free from dust. The aim must be to have the teats clean and sterile and the tea-cups of the machine or the hands of the milker also clean and sterile. It is easier to sterilise the teat-cups than the milkers' hands. The procedure should be as follows:—

(a) Wash the teats with warm soapy water. Wring out the washing cloth and dry off excess moisture.

(b) Sterilise the teats with a solution of hypochlorite. This can be made either from powder or liquid preparations on the market. The strength of the preparation is indicated by the manufacturer in terms of available chlorine, and this should be used to prepare a solution containing at most one part of chlorine to 800 parts of water or not less than one part of chlorine per 1,000 parts of water. *The solution must be made fresh at each milking* and can be applied with a cloth. Another way to apply the solution is to fill a deep (6 inches) narrow (2 to 3 inches) vessel with the solution and to dip each teat in turn into the solution which can be replaced frequently from the bulk solution kept in a bucket. Any excess fluid can be shaken from the teats: don't apply the hand or cloth in an attempt to dry.

(c) Place the sterilised teat cups in position as soon as possible after sterilising the teats.

(d) After milking each cow the cups must be cleaned and sterilised. To clean, plunge them into a bucket of warm water containing washing soda (one heaped dessertspoonful to each gallon) and raise and lower them two or three times. Shake off the water and plunge the cups into a bucket of hypochlorite solution, holding them in this for ten to twenty seconds.

CLEANSING AND STERILISING SOLUTIONS.

The hypochlorite solution will not sterilise a dirty or greasy surface. Therefore, the use as directed of warm soda water is essential. If the teats are sterilised and the cups are sterilised before use, it will be impossible to carry infection from one cow to another. The system must be rigidly observed. Fresh batches of warm soapy water, warm soda water and hypochlorite solution will be required during the milking operations. This applies especially to the soapy water for the teats and the soda water for the cups. They will have to be renewed just as often as necessary according to the number of cows. If any of these solutions become dirty they will contaminate the teats or the cups and their use will do more harm than good.

Sterilisation of the teat cups can be carried out by boiling water or steam where these are available, but heat is damaging to the rubber, especially when it is in contact with the metal.

Other types of disinfectants than hypochlorite are unsatisfactory because of odour, slowness of action on bacteria or destructive action on the rubber of the cups. Potassium permanganate (Condy's crystals) has been used by some people, but it stains most objects badly, is not as good a disinfectant as hypochlorite, and manganese is regarded as a rubber poison; that is, it spoils the rubber.

In hand-milking the same principles are followed and the milkers' hands are washed in soapy water and then in the hypochlorite solution before the milking of each cow.

The care and sterilisation of the milking machine after each milking and the regular weekly dismantling and cleaning should be carried out according to the instruction of the dairy supervisor.

HANDLING OF COWS WITH MASTITIS.

Early recognition of disease in the udder is important. A careful watch should be kept on every quarter at each milking. Slight signs of inflammation can be detected easily enough if looked for. If a quarter is swollen and feels hot it is usually infected. Sometimes there are no signs of swelling or heat in the quarter, but the milk is altered or contains clots. Clots can be detected most easily by passing the first few streams of milk through a fine wire gauze or a so-called strip cup. The use of the strip cup is strongly recommended and the test should be used on every cow once a day if possible.

Any cows showing signs of mastitis should be taken out of the line and milked last.

When purchasing cows make sure they are free from mastitis.

THE HANDLING OF THE HERD.

Calves and pregnant heifers should be kept as far away as possible from the milking herd.

Milking cows should have as much fresh green feed as possible at all times of the year.

When a cow is coming to the end of a lactation period and a decision is reached to dry-off the cow, cut down the food intake, then cease milking altogether and turn it out. Do not practise irregular milking to dry-off a cow. Very heavy producers may need special attention.

De-horn calves so as to lessen the injuries caused to udders by cows horning one another.

SUMMARY OF RECOMMENDATIONS.

(a) Keep to a rigid routine in the milking-shed; aim at rapid and efficient milking and thus remove the necessity to strip cows.

(b) Provide at least four buckets for washing and sterilising udders and teat cups. Use one bucket to contain warm soapy water for washing the udders. Use another to hold a solution of hypochlorite containing one part of chlorine to 800 parts of water. The other two buckets are reserved for the teat cups. One bucket will hold a solution of washing soda (one heaped dessertspoonful to each gallon of water); the other will contain hypochlorite solution (one part of chlorine to 800 parts of water).

(c) Wash the udder with the soapy water and renew this solution frequently before it becomes dirty. Dry out the udder with the wrung-out cloth. Sterilise the teats by washing them with, or dipping them into, the hypochlorite solution, but do not dry. At the end of the milking sterilise all cloths used for washing udders by boiling them in water.

(d) Place the clean sterilised teat cups into position as soon as possible after sterilising the teats. Remove the cups when ready, wash them in warm water containing washing soda and then dip them into the hypochlorite solution for ten to twenty seconds. They are then ready to transfer to the next cow.

(e) For hand-milking adopt the same principles. Wash and sterilise the udder: wash and sterilise the hands before milking each cow.

(f) Remove any cow with mastitis from the line and milk it last.

(g) Purchase only healthy cows free from mastitis.

(h) Keep calves and heifers away from the milking herd.

(i) When a cow is to be dried off cease milking altogether: don't milk irregularly or overstock to dry-off.

(j) De-horn calves.

Vegetable Seed Treatments.

W. P. CASS SMITH, Plant Pathologist.

Many diseases of annual crops and especially vegetables, are caused by parasites which are carried either in, or on the seed, or with the seed, in soil or other impurities.

The term "seed" may here be extended to include not only the true seed, but also plant parts used for vegetative propagation such as tubers, bulbs, and root separations, etc. Very occasionally these organisms may be visible to the naked eye. For example, when potato tubers are affected with the rhizoctonia fungus. Also their presence may sometimes be detected by discoloration of the seed which is often apparent when peas are affected with blackspot or beans with anthracnose.

Generally, however, they are present in the form of bacterial cells or fungal spores loosely attached to the surface of the seed, or as dormant fungal threads within the seed.

Because of their microscopic size, the presence of such seed-borne parasites is, in the great majority of cases, entirely unsuspected, and unless precautions are taken, seed-borne diseases are always liable to occur sooner or later.

This was well illustrated last autumn when serious outbreaks of black rot of cabbage occurred in several districts, including Osborne Park, Balcatta, Wanneroo, and Spearwood, which were attributed very largely to the planting of contaminated seed.

Seed of unknown origin or health should always be regarded with suspicion, especially in wartime, for new and serious diseases may easily be introduced with imported seed.

Various seed treatments are available which minimise this risk, and these can broadly be divided into two main groups, depending on the materials used and the purposes for which they are applied.

(1) *Seed disinfectants* are employed to kill disease-causing fungi and bacteria which are carried on, or in the seed.

(2) *Seed protectants* are applied to protect the seed and young seedlings from pre-emergence damping-off.

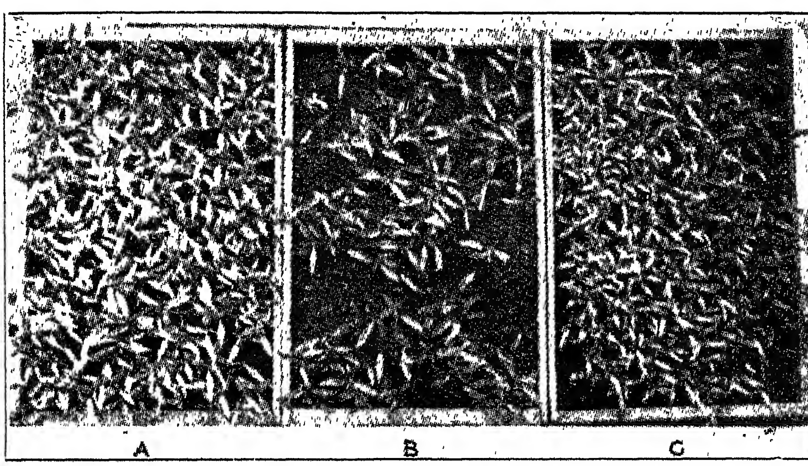

Plate 1.

Pre-emergence damping-off of tomato seedlings controlled by seed protectant dressings. A. Seed dusted with Ceresan. B. Untreated seed. C. Seed dusted with red cuprous oxide.

[After Chamberlain and Brien. N.Z. D.S.I.R. Plant Dis. Div., Bul. 1.]

Seed carrying parasitic organisms *externally* is disinfected by immersing it in fungicidal solutions, or by coating it with fungicidal dusts, and disinfectants commonly used for this purpose are solutions of corrosive sublimate or formalin, or organic-mercury dusts. To kill certain parasites which are carried *inside* the seed, heat is sometimes effectively applied, by soaking the infected seed in hot water.

The dressing of seeds with various dusts to protect them from pre-emergence damping-off has been increasingly practised during recent years. Dusts commonly employed for this purpose consist of organic mercury compounds, e.g. "Agrosan" and "Ceresan"; compounds of copper, e.g. copper oxychloride, cuprous oxide, and copper carbonate; and zinc oxide.

Pre-emergence damping-off is caused by various decay-producing organisms which may be present in the soil or carried by the seed, and which rot the seed, or young seedlings before they emerge through the soil.

This trouble may occur at all times of the year, but it is often most prevalent during winter and spring, when cold wet soil conditions lengthen the period between sowing and emergence.

With present shortages of many vegetable seeds, the use of seed protectant dressings now has an added value; for by producing better stands, considerable savings of seed may also be effected.

Plate 2.

The value of spinach-seed treatment is well illustrated by comparison of the stand in the nine cuprous-oxide-treated rows on the left with that in the five untreated rows on the right.

[After N.Y. (Cornell), Agr. Exp. Sta., Bul. 566.]

For example in a recent local experiment it was found that samples of four popular varieties of garden pea—each showing high germinable capacity in the laboratory—only gave an average emergence of 8 per cent. when planted in soil where pre-emerge damping-off was prevalent. However, when the seed was dusted with copper carbonate prior to planting the emergence increased to 53 per cent.

Seed treatments will often prevent the occurrence of diseases in the garden but they should not be relied on solely for this purpose. Rather, they should be used in conjunction with other control measures such as seed-bed disinfection, crop rotation, and general hygiene practices.

VEGETABLE SEED TREATMENTS.

Seed.	Disease.	Treatment.
		(*For smaller quantities of seed than those mentioned, see under methods.*)
Bean, French and Runner	Bacterial Blight; Anthracnose	Discard all diseased, discoloured, and shrivelled seed.
Beets	Leaf Spot	Dip in formalin 2½ oz. to one gallon of water (= 5 tablespoonsful per gallon or 2½ teaspoonsful per pint) for 7 minutes. Rinse in water and plant at once or dry.
	Pre-emergence damping-off	Dust seed with copper dusts at 2 level teaspoons or organic mercury dusts at ½–1 teaspoon per lb.
Carrot	Pre-emergence damping-off	Dust seed with copper dusts at one level teaspoon or organic mercury dusts at ¼–½ level teaspoon per lb.
Celery	Pre-emergence damping-off	Dust seed with cuprous oxide at 1½ level teaspoons per lb.
	Early Blight; Late Blight	Dip seed in hot water (118° F.) for 30 minutes. Spread out thinly in shade and dry quickly.
Cabbage, Cauliflower, Brussels Sprouts, Radish, Broccoli, and Turnip	Blackleg and Blackrot ..	Immerse seed in hot water (122° F.) 25 minutes for cabbage and 15 minutes for others. Spread thinly in shade and dry quickly.
	Blackrot	Immerse seed in corrosive sublimate 1-1000 strength, 30 minutes for cabbage and 20 minutes for others. Drain and then rinse for 15 minutes in clean running water. Spread to dry in shade. Prepare solution by dissolving ¼ oz. of corrosive sublimate in 1 gallon 4½ pints of water or by dissolving prepared tablets in water as recommended on the container.
	Pre-emergence damping-off	Dust seed with zinc oxide at 2 level teaspoons per lb. *Copper dusts are not recommended as they may cause injury.*
Cucumber, melons, marrow and pumpkin	Pre-emergence damping-off	As for carrot.
	Fusarium Wilt	Immerse seed in mercuric chloride (1-1000) for 5 to 7 minutes. Wash 15 minutes in clean running water and spread thinly to dry in shade.
Lettuce	Pre-emergence damping-off	Dust seed with zinc oxide at 2 level teaspoons per lb.
Onion	Pre-emergence damping-off	As for lettuce.
	Red root	Immerse seed in mercuric chloride (1–1000) for 30 minutes. Wash for 15 minutes and spread thinly to dry in shade.
	Downy Mildew	Immerse seed in hot water (122° F.) for 25 minutes. Spread thinly in shade and dry quickly.
Peas	Pre-emergence damping-off	Dust seed with copper dusts at the rate of 2 oz. per bushel (= 1 level teaspoon per lb.), or organic mercury dusts, 1 oz. per bushel (= ½ level teaspoon per lb.). *Note: Inoculated seed should not be dusted.*
	Foot Rot and Root Rot ...	Discard seed which shows brown or black marks or is badly shrivelled.

VEGETABLE SEED TREATMENTS—*continued.*

Seed.	Disease.	Treatment.
Potatoes	Rhizoctonia, Common Scab	Dip seed, unsprouted and uncut, for 10 minutes in acidulated mercuric chloride (4 ozs. dissolved in 1 quart of commercial hydrochloric acid) added to 25 gallons water. After 10 dippings, extend time to 15 minutes for each of 5 additional dippings, then discard solution. *Plant at once or dry thoroughly and store ; or* Dip in proprietary organic mercury dips according to directions on container.
Rhubarb (roots)	Foot Rot and Crown Rot	Soak roots in mercuric chloride (1–1000) for ½ hour. Wash and spread out to dry.
Spinach	Pre-emergence damping-off	As for beet.
Tomato	Pre-emergence damping-off	Dust seed with copper dusts at 1 level teaspoon or organic mercury dusts at ¼ to ½ level teaspoon per lb.
	Fusarium Wilt	Immerse seed in mercuric chloride (1–3000) for 5 minutes. Wash 15 minutes in clean running water and spread thinly to dry.

METHODS AND MATERIALS.

Dusts are applied by placing seed and dust in a Mason jar or other tightly lidded container, and shaking vigorously for several minutes, until the seeds are evenly coated. Any excess dust should be screened off.

For small amounts of seed, for example, a 6d. packet, it is impossible to recommend a definite measure of dust owing to the variable quantity of seed contained.

In such cases, a pinch of dust may be shaken up with the packeted seeds until they are thoroughly coated, and the excess dust screened off.

Hot Water Treatments.

This must be carried out with care and accuracy for the temperature required to kill a seed-borne pathogen is not much below that at which seed injury occurs. The duration of treatment is also important, for prolongation beyond the recommended period increases liability to injury. To ensure uniform temperature conditions during the steep, a large volume of water in proportion to seed should be used, e.g., ¼ to ½-lb. per 4 gallons. A suitable container, such as a kerosene tin fitted with a lid in which two holes have been bored, is nearly filled with water at the required temperature and well insulated with straw, chaff or bran, etc., either in a box or hole in the ground. The seed, tied loosely in a cheesecloth or muslin bag, is then suspended in the hot water and the tie passed through a hole in the lid.

Through the other hole, an accurate Fahrenheit thermometer is inserted.

During treatment the seed should be well agitated, but care should be taken to avoid wetting the insulating material. Boiling water should also be on hand to maintain the temperature as required. After treatment dry the seed as rapidly as possible by spreading it out thinly in the shade and stir it to promote air circulation.

Weak seed should not be treated, therefore if the quality is doubtful, a trial sample should first be tested.

Corrosive sublimate (mercuric chloride) is a *deadly poison* and it also corrodes metals. It should therefore be kept well out of reach of children and animals, and solutions should be prepared in glass, enamel, or earthenware vessels, etc.

Corrosive sublimate may be purchased in powder or tablet form from wholesale or retail chemists.

To prepare a 1:1,000 solution, 1 tablet is dissolved in 1 pint of water, or 1 ounce of the powder dissolved in 6¼ gallons of water. As the chemical is only slowly soluble in cold water, it should be dissolved in a little hot water, and water added to make the final volume.

Small quantities of solution are most conveniently prepared with tablets, but when larger quantities are required, the powder form of corrosive sublimate is cheaper.

In the latter case the most convenient method is to prepare a stock solution containing 2 ounces of the corrosive sublimate powder in 1 gallon of water, and to dilute portions of this for use as shown in the table below.

DILUTION TABLE FOR MAKING 1 IN 1,000 CORROSIVE SUBLIMATE, USING A STOCK SOLUTION OF **TWO OUNCES IN ONE GALLON.**

Stock Solution. Take amount indicated below.	Dilute with clean cold water in wooden, glass, cement, or earthenware container to final volume indicated below.
(a) ¼ pint	3⅛ pints
(b) ½ pint	6¼ pints
(c) ¾ pint	1 gallon 1⅜ pints
(d) 1 pint	1 gallon 4½ pints
(e) 1½ pints	2 gallons 2¾ pints
(f) 1 quart	3 gallons 1 pint
(g) ½ gallon	6 gallons 2 pints
(h) 1 gallon	12½ gallons

Formalin.—Commercial formalin (40 per cent. formaldehyde solution) has a pungent odour and it is irritating to the eyes. It does not attack metals.

At present this material can only be released for commercial growers but the position may change. It is useful not only for disinfecting seed against certain diseases but also for sterilising soil.

Organic mercuric dusts are sold under various proprietary names. *"Agrosan"* may be obtained from Elder Smith & Co., Ltd., or agents; *"Ceresan"* from Dalgety & Co., Ltd., or agents; and both are stocked by seedsmen.

Copper Dusts—

Copper carbonate is widely used in this State for dry pickling wheat against bunt or stinking smut. It is stocked by practically all firms with agricultural interests, by large stores, and by seedsmen. In future it may be in short supply in which case it may be replaced by copper oxychloride, or cuprous oxide.

Copper oxychlorides are sold commercially under such proprietary names as "Smutol," "Cuprox," and "Soltosan."

"Smutol" has been mainly used in the past for dressing seed wheat, and "Cuprox" and "Soltosan" as Bordeaux-mixture substitute sprays. All three substances may be used, however, for dressing various vegetable seeds.

"Smutol" and "Cuprox" are obtainable from Elder Smith and Co., Ltd., or agents, and from seedsmen, while "Soltosan" may be purchased from Paterson and Co., Ltd., or seedsmen.

Cuprous oxide was formerly sold here, as a spray material under the proprietary name of "Peronox." Limited supplies of "Peronox" and also red cuprous oxide are still available from Elder Smith and Co. and seedsmen. Seed treated with this substance, unless planted immediately, should be kept in an airtight container to avoid spoilage through oxidation.

"Hortosan" and "Aretan" are proprietary organic-mercury compounds which have been developed for quick potato dips. They are very convenient for the home gardener as the time of immersion is short, but they are probably not so effective as the longer corrosive sublimate dips.

"Hortosan" is obtainable from Elder Smith and Co., Ltd., or seedsmen, and "Aretan" from Paterson and Co., Ltd.

Stocks of these materials are at present limited and they may become more difficult to obtain in future.

Zinc oxide is a relatively mild seed dressing. It may be purchased from any chemist but as finely divided a form as possible should be used.

Precautions.

Most of the materials mentioned are poisonous in varying degrees, therefore the usual precautions should be observed when storing or applying them.

Orchard Notes.

A SEEDLING APPLE WITH PROMISE.

The following interesting report has been received from Mr. V. Cahill, Horticultural Instructor of Mundaring, and it appears that the seedling apple so much resembling Delicious may be a decided acquisition. The variety will be kept under observation, and it is hoped that it will be tried out in other districts:—

"When completing my visit to the Manjimup District on the inspection of apple scab, I chanced to visit the orchard of Mr. T. G. Trebilco, in that district. on the 4th June, 1940, and was interested to find apples which resembled the Delicious, both in appearance and flavour, still on the tree so late in the season. On examination of the tree I found it to be a seedling, 15 years or more old, bearing well.

"Being interested in the fruit I selected several scions from this seedling tree and grafted them on a tree at Chidlows in September of that year.

"The scions made good growth during the season 1941-42, and again this year, yielding over half a bushel of fruit this season. The apples were picked in the last week in May. The fruit appears to be true to the parent type at Manjimup.

"For the colour, appearance and taste, it could be classified as a late Delicious, and grown as a commercial apple. The tree is a sturdy, vigorous grower with good foliage and spur system, also a free bearer."

HOME PRESERVATION OF CITRUS JUICES.

W. J. BETTENAY, Horticultural Instructor.

The value of citrus juices in our diet has been fully realised only in recent years. Quite apart from their thirst quenching qualities, which are undoubtedly great, the secret of their importance is in their high Vitamin C content. Vitamin C is essential for the prevention of scurvy. In Australia only rare cases of scurvy have occurred. Nevertheless, even if symptoms of acute scurvy are not present, it is possible for the body to be seriously affected because of the lack of Vitamin C. Children in particular may suffer from Vitamin C deficiency without exhibiting active symptoms of scurvy.

The main citrus juices in Western Australia are grapefruit, orange and lemon. Of these, orange juice is perhaps the best source of Vitamin C, but that of lemon juice is more stable in storage.

In preparing the juice, an ordinary glass cone squeezer can be used. The fruit is cut in halves and the juice extracted with a certain amount of pulp, but care must be taken not to include the oils from the outer yellow rind as these will tend to spoil the flavour. The juice may be strained or the pulp may be left in; some claim that by leaving it in the flavour is improved. The juice should be placed in an enamelled, glass or china container, and transferred quickly to glass bottles, which should be filled to within one inch of the tops and tightly corked. Brown bottles should be used as clear glass bottles allow the entry of light, which accelerates the destruction of Vitamin C.

Having obtained the juice there are two main methods of preserving it.

1. *Heat Method.*—The corks must be securely tied into the bottles with string. They are then put into a kerosene tin or copper so that when filled with water the water level comes nearly to the top of the bottles. Heat the water to 170° F., and hold at that temperature for 25 minutes. Remove the bottles and lay on their sides for several minutes, then store in a cool dark room.

2. *Chemical Method.*—The use of chemical preservatives inhibits fermentation which often causes deterioration. The following method utilises a preservative known as sodium meta-bisulphite, and it can be secured at any pharmaceutical chemist's shop. Commercial grade of this preservative costs in the region of 4/- per lb. and the quantity recommended is at the rate of one level teaspoonful to each gallon and a half of juice. The chemist probably will be able to weigh out small quantities and, if so, one gramme quantities should be used for each half gallon of the juice.

Should the chemist be only in a position to supply chemically pure sodium meta-bisulphite, the quantities recommended for commercial grade should be reduced by one third and used as follows:—

1 gramme for each ¾ gallon juice

1 teaspoonful for each 2¼ gallon juice.

The preservative should be well stirred into the juice immediately before bottling, and the filled bottles should be stored in a cool dark room.

Should sodium meta-bisulphite not be available, sodium benzoate can be used at the rate of:—

1 teaspoonful for each gallon and a half of juice

1 gramme for each half gallon of juice.

Fruit for juice should be freshly picked, and the juice after extraction needs prompt handling. All contact with metal, especially copper, should be scrupulously avoided.

Even if all precautions are taken the amount of Vitamin C in the juice decreases slowly with storage, and by the end of six months the juice is not necessarily high in Vitamin C. Orange juice loses Vitamin C faster than does lemon juice. The addition of some lemon juice to orange juice helps to retain Vitamin C.

After opening a bottle the contents deteriorate rapidly, and by the end of two weeks all Vitamin C may have gone. It is suggested that for small families, small bottles be utilised for containing the juice to avoid waste.

In addition to Vitamin C, other vitamins are to be found in citrus juices, and they include Vitamin B1, Vitamin G (B_2) and Vitamin A, all being essential to good health.

Blue Prussian or Blue Boiler Peas.

M. CULLITY, Superintendent of Dairying; H. G. ELLIOTT, Agrostologist.

Blue Prussian, or blue boiler peas were produced for export in relatively large quantities in Tasmania in the pre-war years. Since the outbreak of war with Japan and the concentration of large military forces in Australia the demand for the peas has increased.

They have several attractive features, not only for their nutritive qualities but also because they are particularly easy to transport and can be kept without spoiling for long periods. Small quantities have been used in Western Australia as loose peas, while in England they have been known over a long period as packet peas.

In preparation for use the peas are soaked for 1-2 days or longer. It has been demonstrated that by prolonging the period of soaking up to four days, by which time the peas will have sprouted and the rootlets be approaching one inch in length, the vitamin content is greatly improved. Their great value in feeding the men in the defence forces in remote areas, therefore, can be readily appreciated.

Owing to the greatly expanded requirements the mainland States were asked to endeavour to grow large areas.

Following this request a quantity of seed was imported into this State in 1942, and was made available to prospective growers on the basis of the cost of the seed being a charge against the proceeds of the crop. As the result 1,000 acres were sown, but unfortunately, owing to the unavoidable lateness of planting most crops sown in areas of light rainfall did not have sufficient moisture to allow satisfactory development of pods. In other areas where moisture conditions were favourable grub attacks were responsible for failures.

A special arrangement was also made by which the Field Pea Board guaranteed to purchase all crops on a scale graduated according to the purity of sample. While farmers were instructed to fumigate their peas as a precaution against the development of pea weevil, peas showing their presence were purchased and later sold to stock feed merchants.

Farmers were impressed with the possibilities of growing this crop, as a result of their experiences last year, and between 900 and 1,000 acres have been sown this season, although the conditions laid down by the Field Pea Board on behalf of the Commonwealth Government have required payment for seed in advance and suggest a more rigid basis of purchase.

The system of contracting with the grower to purchase his crop, if it is equal to "A" grade quality, is a guarantee that the crop if harvested and fumigated efficiently will be purchased at 15s. per bushel. There is also an implied agreement that peas of lesser quality will be purchased, providing they are capable of being cleaned to "A" grade quality. Payment for these would naturally be at a reduced price on the basis of the cleaned weight.

The specification of "A" grade is as follows:—

Prime, over ¼in.	60 %
Crinkle, over ¼in., not more than	20 %
Under ¼in., not more than	19 %
Broken, not more than	½ %
Sprouted, not more than	⅛ %
Foreign varieties, not more than	⅛ %
Foreign matter, not more than	¼ %
	100 %

It is expected that this year's experience with the crop will encourage farmers to expand their areas next year, and it appears that an opportunity will be present for this State to grow up to 3,500 acres.

Farmers are therefore requested to consider whether they can assist by making preparations on a larger scale for next season's crop.

For intending growers the following notes on the cultivation and harvesting of the crop are given.

Soil Requirements.

Well drained light to medium soils that are neutral or of low acidity are best suited to these field peas. Heavy soils rich in humus tend to produce a heavier growth of vines with comparatively fewer pods with a consequent smaller yield of seed. They will not grow well where standing water occurs or where the soil is constantly waterlogged or boggy.

Soil Preparation.

Land which has been fallowed would give best results, but early ploughing in the autumn with subsequent cultivation will give good results. It is essential that a good clean seed bed be obtained—this would tend to check the ravages of the red-legged earth mite and reduce the incident of weeds.

Time of Sowing.

This varies according to the districts, from May in medium to light rainfall areas, to end of July in the higher rainfall districts.

Rate of Seeding.

In the high rainfall areas up to 120 lbs. per acre; in the medium rainfall areas from 90 lbs. per acre, and in the lighter rainfall areas 60 lbs. per acre.

Method of Seeding.

Field peas are best sown with a grain drill either hoe or disc type. Drills should be used in preference to broadcasting the seed by hand. In any drill care must be taken to see that the feed in the drill does not crack the seed. Where a drill is not available the seed can be broadcasted by hand and covered with a spike tooth harrow or cultivator. The peas should be planted not less than 2in. deep. Laboratory tests show that good pea seed will germinate over 90 per cent., as little or no hard seeds occur in samples.

Fertiliser.

It is usually recommended to apply from 1½ to 2 cwts. of superphosphate per acre at the same time as sowing the seed.

Inoculation.

For best results these peas should be inoculated, more particularly when they are being sown on land which has not previously grown peas. The culture for inoculating can be obtained on application from the Department of Agriculture, a bottle costing 5s. will do up to four bushels of seed. It is necessary to order the culture at least two weeks before planting commences. Full instructions as to how to inoculate the seed are supplied with the culture.

Insect Pests.

In the initial stages of growth red-legged earth mite can cause a considerable amount of damage, and reduce the ultimate stand and yield of peas. Good clean fallow or good ploughing, by turning the sod completely under, will help reduce the severity of the attack. It is recommended that a good border of oats be planted round the crop to help stop encroachment of the mite from unploughed headlands.

The most serious pest of the field pea in this State is the pea weevil (*Bruchus pisorium*) and it has done more than any other pest in limiting the acreage of this crop.

Diseases.

The main disease which occurs is Black Spot. On page 42 of the June, 1943, issue of this Journal, an article written by W. P. Cass Smith, Plant Pathologist, gave information with reference to this disease and its control.

Harvesting.

The quickest and most simple method of harvesting is by a pea header attachment. In this case the peas are lifted by means of mechanical fingers on the pea front attachment of a header. The seed is threshed from the pods and the vines and empty pods are discharged at the rear of the machine.

Where these machines are not available, harvesting is usually carried out by the following method:—

It is recommended that the peas for seed be cut with a mower when the pods are nearly mature and the seed is firm. It is not advisable to wait until the vine and pods are both dry as under such conditions bleaching, loss from shattering, and weevil damage will occur. The peas are most commonly cut with the ordinary mower and wind rowed, then stacked and threshed by ordinary grain separators or threshing machines.

Control of Pea Weevil.

For farmers who are growing these peas the following notes on the control of pea weevil have been prepared by the Government Entomologist, Mr. C. F. H. Jenkins.

In order to ensure good samples of peas suitable for human consumption and canning, the following recommendations should be observed:—

1. Harvest the peas as early as possible.
2. Fumigate immediately after harvesting.
3. On no account delay treatment, as weevil grubs, although not apparent, may be feeding within the peas.
4. Use carbon bi-sulphide at the rate of from 4-20 lbs. or 2½-12½ pints per thousand cubic feet of space, according to the amount of leakage from the fumigation chamber.
5. Leave sealed for 48 hours.
6. Fumigate during warm weather when possible.

How to Fumigate.

Any airtight container of suitable size can be used for fumigation. If a room is utilised, the windows, ventilators, and all cracks must be pasted up with thick paper or otherwise sealed to prevent the escape of gas.

Tanks have been used successfully by many farmers.

A large tank may be rigged with block and tackle and lowered over stacked bags. The ground contact should be sealed with heaped up soil.

A sound tarpaulin may be used to cover stacked bags, but great care must be taken to prevent leakages.

For small quantities a sound 200-gallon tank (holds eight tipped bags) with the lid sealed with moist clay, is very effective.

Dosage Required.

1,000 gallon tank requires ¾ pint of carbon bi-sulphide.

200 gallon tank requires ¼ pint of carbon bi-sulphide.

Room 10ft. by 10ft. by 10ft. = 1,000 cubic feet, requires 2½ pints.

If leakage is suspected these dosages may be more than doubled without injury to dry seed.

Method of Application.

The gas generated is heavier than air, therefore the liquid fumigants should be placed on the *top* of the peas. It may be poured direct on to the bags or placed in shallow containers on the top of the stack. Where it is desired to treat tipped peas in a bin deeper than about 5 ft. some of the fumigant should be introduced into the centre of the mass through a long pipe.

Warning.

Carbon bi-sulphide is explosive and inflammable. Rooms should be ventilated after treatment before being entered.

Nitrate of Soda.

ITS USE IN AGRICULTURE.

L. J. H. TEAKLE.

"Nitrate of soda has been recognised as one of the standard nitrogen carriers for over a century." This statement was made by Dr. F. Moser of Purdue University, Indiana, in his discussion of the value of nitrogenous fertilisers for agriculture. It represents the considered conclusion of an authority on American agriculture.

Nitrate of soda is a suitable source of nitrogen for fruit trees and is extensively used for this purpose in many parts of the world. Best results are obtained by applying just before flowering.

NITROGENOUS FERTILISERS IN WESTERN AUSTRALIA.

In Western Australia, nitrate of soda does not enjoy the popularity accorded it as a fertiliser in the older agricultural countries. Its use has been confined largely to the topdressing of vegetable crops. Sulphate of ammonia, on account of its abundant supply, has been much more generally used and is highly favoured by Western Australian farmers, particularly for potato, vegetable and orchard growing.

However, the situation is that no one source of nitrogen can be considered best for all soils under all conditions.

On the average on the more fertile soils, all ordinary types of nitrogenous fertilisers are equally efficient. Where the soil is inclined to be sour and low in lime, sulphate of ammonia induces soil deterioration and increases sourness. To maintain soil fertility adequate lime must be used in conjunction with sulphate of ammonia. Sulphate of ammonia is often less efficient on heavy clay soils owing to the absorption of the ammonia by the clay. On alkaline or heavily limed soil, ammonia may be lost by volatilisation. Nitrate of soda or nitrate of lime would be more effective nitrogenous fertilisers under these conditions.

Where the soils are light and readily leached by rain or irrigation water, as is the case in many parts of Western Australia, nitrate of soda must be used with judgment. In the wet winter months, on these soils it is likely to be ineffective if all applied at planting time, as it is liable to be washed out of the soil before the crop makes sufficient root growth to use it and take advantage of its value as a source of nitrogen.

Generally, nitrate of soda is at least as efficient as other forms of nitrogen for the growth of crops, but owing to its high solubility and ready availability it must be used with caution and in accordance with the soil and climatic conditions prevailing. Instances of poor results from nitrate of soda are almost invariably due *to its improper use* and not to the ineffectiveness of this form of nitrogen.

THE USE OF NITRATE OF SODA.

While growers may use their discretion and purchase the fertiliser of their fancy in peacetime, wartime conditions make it necessary to use whatever is available. The problem is to get the highest efficiency from all operations and to do this the farmers may have to modify their methods according to the properties of the fertiliser supplied. As supplies of nitrate of soda are now available for the State, maximum use may be made of it as it is impossible to get anything like normal quantities of sulphate of ammonia and blood and bone. The nitrate of soda has been obtained from Chile at considerable cost to the Commonwealth Government and is a very fine sample of the modern granulated fertiliser. In this condition it does not readily absorb moisture from the air and, in consequence, does not become sticky and nasty to handle. It readily mixes with superphosphate and the mixture maintains good physical conditions.

The following recommendations are made for the use of nitrate of soda in Western Australian agriculture:—

1. Use nitrate of soda in small amounts with superphosphate at planting for special annual crops sown in the low rainfall months of the year. The equivalent of from 1 to 2 cwts. of nitrate of soda per acre should be adequate at planting time.

2. Apply the remainder of the nitrate of soda available after the crop has effected a vigorous establishment and the rooting system has been developed to absorb the nitrate without danger of loss by leaching. Up to 4 cwts. of nitrate of soda per acre may be applied in one or more applications.

Split dressings of the readily available nitrogenous fertilisers are much more effective than all applied at one time—for instance, at planting. Two or more top-dressings with nitrate of soda up to the limit available are important in promoting growth and crispness in green vegetables such as cabbages, lettuce, silver beet, etc.

3. Nitrate of soda makes an excellent liquid manure when dissolved in water at the rate of one to two ounces per gallon. In this condition it is particularly effective for use with cabbages and similar vegetables a few weeks prior to cutting.

4. Do not apply nitrate of soda or mixtures containing nitrate of soda at planting in the wet months or under heavy sprinkler irrigation on sandy soils. As far as possible, fertiliser mixtures containing sulphate of ammonia for vegetable and potato crops will be made available for May to August planting. In the wet months use nitrate of soda for topdressing the crop after becoming well established.

5. For fruit trees, nitrate of soda should be applied either singly or mixed with other fertilisers about September. If applied too early there is danger of loss by leaching. Owing to limited supplies 3 cwts. of nitrate of soda per acre for citrus, 2 cwts. per acre for stone fruits and vine fruits and 1 cwt. per acre for apples and pears are allowed by the Fertiliser Rationing Office. These quantities, although considerably smaller than that advised by many horticulturists, will prove very efficient and valuable for these orchard crops.

Soil Moisture Conservation in Vineyards and Orchards.

ITS RELATION TO CULTIVATION, COVER CROPS, AND WEEDS.

G. H. BURVILL, L. J. H. TEAKLE, and L. T. JONES.

SUMMARY.

Experiments involving various cultural and mulching treatments have been carried out at Upper Swan during the spring and summer seasons of 1941-42 and 1942-43 on well drained alluvial soil similar to that in some of the Swan vineyards.

The results have confirmed the conclusions of investigators in many parts of the world that a loose dry soil mulch is, under these conditions, no more effective in conserving moisture than an unmulched surface provided the latter is free of weeds. Weeds are the major controllable factor in soil moisture losses during summer.

Heavy cover crops or green manure crops have been found to cause a big drain on soil moisture to a depth of six feet after mid-September.

Straw or similar mulching material spread on the soil surface did not give any practical advantage in moisture conservation.

It is suggested that for orchards and vineyards in Western Australia recent American recommendations might well be followed. This would involve the discing-in of green manure and cover crops in late August and early September leaving a rough trashy surface. A similar cultivation in October would control weeds. Soil erosion and deterioration of soil structure would be reduced to a minimum.

INTRODUCTION.

A widespread belief still exists among orchardists, farmers, and gardeners, that the periodic cultivation of surface soil to produce a fine loose mulch results in a saving of moisture which would otherwise be lost by evaporation. The soil mulch itself is credited with being able to prevent moisture losses, and the common explanation is that the so-called "capillary movement" of water from the subsoil to the surface is interrupted and hindered by a loose surface mulch.

During the past thirty years many investigations of soil moisture and soil management have failed to support this idea, and have even shown that too much cultivation can be damaging to the soil structure and reduce soil productivity. Then again, the costs of cultivation and the soil erosion menace have brought cultural practices into critical review during recent years, with the result that new methods, usually involving less frequent stirring of the soil, are commonly advised.

To quote Charles E. Kellogg* (1941) from his book, "The Soils that Support Us," page 222:—

"On the whole, modern farmers in the United States still plow and cultivate too much." And page 223—

"Rather than 'plow deep while sluggards sleep' one should plow well, at the proper time, and as little as possible, yet kill weeds, develop good seed beds, and make the soil receptive to rain water."

In a climate with winter rainfall and a dry, hot summer, as in the south-west of Western Australia, soil moisture conservation is vital for non-irrigated orchards and vineyards.

To obtain local data on mulches, cultural practices, and weeds in their relation to soil moisture, experiments have been conducted during the 1941-42 and 1942-43 summers at "Belhus," Messrs. Barrett-Lennard Bros.' property at Upper Swan. The Superintendent of Horticulture (Mr. H. R. Powell) suggested the desirability of local information, and the experiments have been carried out by the collaboration of officers of the Plant Nutrition and Horticultural Branches. Before passing to a consideration of these experiments a brief review of investigations on soil cultivation and mulching will be of interest.

REVIEW OF INVESTIGATIONS ON SOIL MULCHES AND CULTIVATION.

King at Wisconsin, and Hilgard and Loughridge in California, studied soil moisture conservation extensively towards the end of last century and considered that during dry periods soil moisture moves upwards to the surface by capillarity and there evaporates. They strongly recommended careful and thorough cultivation of the soil surface to maintain a loose dry soil mulch which would break the fine capillary tubes and so reduce the upward capillary movement. These recommendations became an important feature of dry land agriculture and the "dust mulch" idea became strongly ingrained into farming practice, especially for orchards and vineyards which are not irrigated and which make their growth during a relatively dry season. Since as early as 1910, however, many investigators, especially in America, have questioned the value of the soil mulch in moisture conservation, and, in 1915, Chilcott, Cole and Burr in the United States Department of Agriculture Bulletin, No. 268, summarised the results of a number of trials. They concluded that, provided there is no plant growth, the loss of water is practically the same from a mulched* surface as an unmulched one. Keen, of Rothamsted, in "The Physical Properties of the Soil" published in 1931, reviewed the evidence concerning the value of the mulch in soil moisture conservation and concluded that except under special conditions it is no more effective than a bare uncultivated surface. The special conditions referred to are when the free water table (as in a well) is within about six feet of the surface. Under these conditions

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* Unless stated to the contrary, a reference to a mulched surface implies a loose layer of soil on the surface produced by cultivating implements. The use of straw, sand, paper, gravel, etc., as mulches will be referred to specifically.

capillary movement can take place fairly rapidly and a loose soil mulch on the surface has been shown to be effective in reducing losses. In fact, a number of early experiments which brought the soil mulch into favour were done under laboratory conditions with the soil in tubes or cylinders standing in a reservoir of water. King carried out experiments under such conditions, and Shaw in California, in 1927, found that with a water table at four feet, the loss from two unmulched soil columns was more than 60 per cent. greater than that from columns of similar soil mulched two inches deep. The mulch was well stirred six times during the experiment after the initial mulching. An experiment under similar conditions showing the value of soil, manure, and grass mulches was reported by Throssell (1924) in this Journal.

A number of investigators in U.S.A., Canada, South Africa and Australia during the past 15 years have confirmed that, in moisture retention under field conditions with no shallow water table, only very slight advantage, if any, certainly nothing of practical importance, is achieved by creating a loose soil mulch. The important thing is that weed growth should be reduced to a minimum.

Early ideas with respect to soil mulching were based on the assumption that moisture could move through the soil by the process of capillarity just as oil moves through the wick in a lamp. It has been proved more recently, however, that capillary movement of moisture from wet to dry soils is very slow below field capacity—that is, below the maximum moisture content which a well drained soil can hold.

Straw, Paper, Sand and Gravel Mulches.

It has been shown at various times that mulches of straw, paper, sand, and gravel are effective in conserving soil moisture. Straw, leaves, manure, grass, etc., are often used around shrubs and the straw mulch is used in some of the orchards of Eastern U.S.A. for various benefits. An experiment carried out in tanks at Merredin Research Station in the past 12 years has shown clearly that much more moisture is conserved in heavy clay loam under a sand layer five inches thick, than under a loose soil mulch of the same heavy soil. This is because the rains pass more easily through the sand layer than through a layer of heavy soil of the same thickness, and also because the sand reduces the losses during dry periods. Some of the recent American work by Russel of Nebraska suggests that straw mulches are effective in periods when water is being periodically added to the soil—as under summer rainfall conditions—but no more effective than a soil mulch (or bare soil presumably) in long dry periods.

EXPERIMENTS AT "BELHUS"—UPPER SWAN.

The experimental site used at "Belhus" is located in a flat portion of a grazing paddock on alluvial soil similar to parts of the "Belhus" vineyard. It is well above the levels of Ellen's Brook and the Swan River, and no water table occurs within nine feet of the surface—it is probably much deeper. The chocolate loamy fine sand surface soil becomes red brown below two feet and continues so beyond six feet without any clay layers, so that it must be regarded as relatively light soil. When selected in August, 1941, the area carried a fine stand of New Zealand blue lupins and some wild radish estimated at 18 tons of green material per acre. This was similar to a very good vineyard or orchard green manure crop. A similar but variable growth of lupins, radish, and grass was on the plots in the 1942 winter.

Seven treatments involving cultural variations were decided on, and to repeat each five times, 35 plots each 10 feet square, were marked out in an area 70 x 50 feet. A random arrangement of the treatments was used within each of the five blocks of seven plots. The third week of August was chosen to commence the treatments as this is a common time for ploughing-under of green manure crops in the Swan vineyards. A second ploughing is often made in early October. The general treatments adopted in spring and summer seasons of 1941-42 and 1942-43, have been:—

A. Cover crop dug in August, second digging October. No cultivation thereafter during the summer.

B. Cover crop dug in August, second digging October, cultivation to about three inches at approximately monthly intervals to maintain loose soil mulch.

C. Cover crop allowed to grow to maturity—no cultivation.

D. Cover crop cut at ground level and removed in August and bare smooth surface maintained during spring and summer. No digging or cultivation.

E. Cover crop removed as in D but otherwise treated as A.

F. Cover crop cut in August and allowed to lie on surface as a mulch. No digging or cultivation.

G. Cover crop dug in August, second digging October, when a mulch of straw (1941) or green lupin plants (1942) was applied at approximately four tons of dry matter per acre.

In order to establish whether the soil mulch of treatment B possessed any virtues in moisture conservation, apart from the weed control achieved in producing the mulch, it was necessary to remove any weed growth from treatment A plots. This was not achieved in the period October-December, 1941, but subsequently and in 1942-43, weeds were carefully eliminated.

The moisture changes in the soil were determined by periodic samplings of all plots to a depth of six feet with a four inch post hole auger. Samples for moisture were taken in each case to represent the following layers: 0-6in., 6-12in., 12-24in., 24-36in., and 36-72in. Each hole was carefully filled and rammed after sampling and the sample holes were confined to an area five feet square in the centre of the 10 feet square plot. Five samplings were made from 20th August, 1941, to 19th March, 1942, and six samplings from 24th August, 1942, to 16th February, 1943.

RESULTS, 1941-42 SEASON.

The moisture data from the 1941-42 samplings are illustrated graphically in Figure 1 which also shows the rainfall at "Belvoir," about one mile away, during the same period. Actually a fall of 78 points recorded at "Belvoir" on 19th March has not been included because sampling of the plots was done on 18th and 20th March, and there was no indication that such a fall had occurred on the plots. Thunderstorms were common at this period and these are known to be associated with falls of rain over limited areas. The data are shown for the two layers

0-3 feet and 3-6 feet. To avoid confusion only four treatments, A, B, C, and D, are illustrated. E gave results substantially the same as A, while F and G were more closely related to B and D.

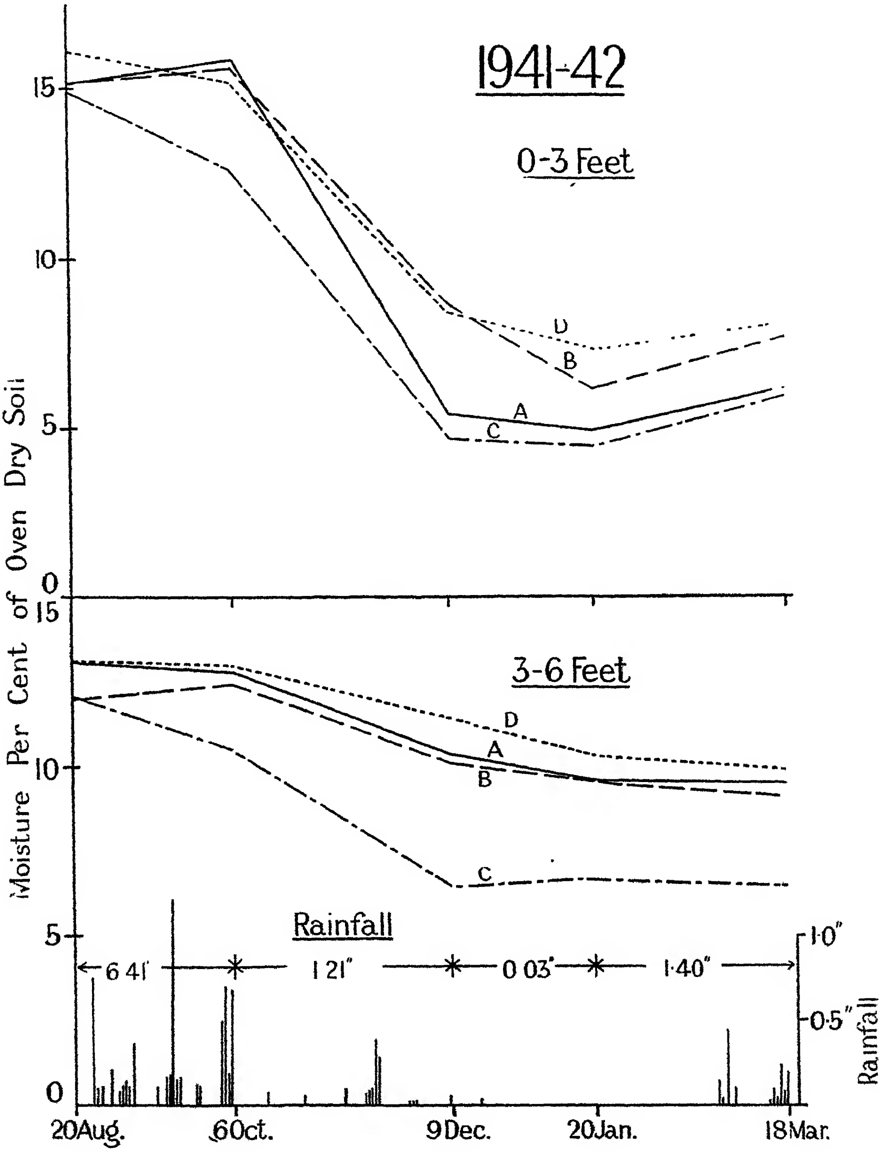

Fig. 1.

Soil moisture changes under various cultural and mulching treatments during spring and summer, 1941-42:—

A.—Cover crop dug in 20th August. Second digging 6th October. No summer cultivations. Vigorous weed growth developed 6th October to 9th December, but afterwards controlled.

B.—Cover crop dug in 20th August. Second digging 6th October. Cultivated to 3 in. at intervals during summer (30th October, 10th December, 7th and 21st January.)

C.—Uncultivated. Lupin and radish cover crop grew to maturity.

D.—Bare smooth uncultivated surface. Cover crop removed 20th August, and weed growth chipped at intervals when B was cultivated.

Table 1 sets out the 1941-42 data in a different form. It shows the net gains or losses of moisture expressed as inches of rain during the various intervals between samplings. In this soil one per cent. of moisture to a depth of six feet is equivalent to one inch of rain.

TABLE 1.

EFFECT OF VARIOUS CULTURAL AND MULCHING TREATMENTS ON SOIL MOISTURE LOSSES DURING SPRING AND SUMMER, 1941–42.

(All figures expressed as inches of rain.)

Treatment.	Net Gain or Loss of Moisture to 6 feet deep.				Net Total Loss, 20–8–41 to 19–3–42.		
	20–8–41 to 6–10–41.	6–10–41 to 9–12–41.	9–12–41 to 20–1–42.	20–1–42 to 19–3–42.	0–6 ft.	0–3 ft.	3–6 ft.
A. Cover crop dug in 20th August. Second digging 6th October. No summer cultivations. Vigorous weed growth developed 6th October to 9th December, but afterwards controlled	+0·2	—6·5	—0·6	+0·7	6·2	4·35	1·85
B. Cover crop dug in 20th August. Second digging 6th October. Cultivated to 3 in. at intervals during summer (30th October, 10th December, 7th and 21st January)	+0·4	—4·7	—1·5	+0·6	5·2	3·75	1·45
C. Uncultivated Lupin and radish cover crop grew to maturity	—2·0	—6·0	+0·1	+0·6	7·3	4·45	2·85
D. Bare smooth uncultivated surface. Cover crop removed 20th August and weed growth chipped at intervals when B was cultivated	—0·5	—4·2	—1·1	+0·2	5·6	3·95	1·65
E. Cover crop removed 20th August and plots dug as in treatments A and B. Weed growth developed and treated as on A	+1·1	—7·5	—0·7	+0·9	6·2	4·45	1·75
F. Cover crop cut and allowed to lie on surface. No cultivations but weeds chipped as on D	+0·8	—5·9	—0·4	+0·2	5·3	3·85	1·45
G. Cover crop dug in 20th August Second digging 6th October, and straw mulch (4 tons per acre) then applied. Weed growth controlled by plucking	+0·1	—5·0	—0·7	+0·3	5·3	3·75	1·55
Rainfall during same periods . .	inches 6·41	inches. 1·21	inches 0·03	inches. 1·40	inches. 9·05		

In considering both the graph and the table it should be remembered that small differences between the various treatments may be due to soil variability and to chance sampling errors. The detailed sampling showed that the soil was not as uniform as would have been expected, and at the first sampling of the plots on 20th August, 1941, before the treatments were commenced, the plots allocated at random to treatment D had a higher average moisture content to six feet than the other groups of plots.* This can be seen from Figure 1 which clearly shows the variations at the outset of the experiment.

In August and again in early October, except where the lupins and radish were still growing (C) the soil had as much water as it could hold—it was at field capacity—and it contained the equivalent of 14 inches of rain to six feet deep. Yet from 6th October to 9th December even the most effective moisture conserving treatments, B and D, showed a net loss of 4.7 and 4.2 inches of rain, respectively. The heavy weed growth of wild radish on A and E greatly increased this loss, while the maturing of the lupin cover crop on C caused a net

* Statistical analysis showed that D contained significantly more moisture than all other treatments at P = .05. Since prior to this date all plots were under cover crop the result must have been due to soil variations and chance sampling errors.

loss of eight inches from 20th August to 9th December. The intermediate losses of F and G were due to better weed control, especially after 30th October, than on A and E, but another factor accounting for greater net losses than on B and D may have been that the light November rains were insufficient to add much to the soil after wetting the surface mulch of straw (G) or the cover crop remains (F).

After 9th December the summer was very dry till the thunderstorms of late February and mid-March. During this dry period, some further loss of moisture occurred from the soils under treatments B and D. This was because these soils were still somewhat more moist than the others and evaporation continued until this surplus was removed. Under all other treatments the soil moisture had been previously reduced by 9th December to a minimum below which further loss by evaporation was practically eliminated. Because of thunderstorms in the week preceding the March sampling all treatments were moistened in the surface layers and a net gain is shown in Table 1. The graphs of Figure 1 show that the gain was in the upper layers while the 3-6 feet layer showed a further small loss, except for treatment C, which, owing to the action of the cover crop, had been previously reduced to the minimum attainable under natural conditions.

Real differences in the effects of the various treatments (except for C) were apparently confined to the first three feet and for this reason the data for 0-3 feet and 3-6 feet are shown on separate graphs in Figure 1. It will be seen later from Figure 2 that in the 1942-43 season the differences in effect were confined to the upper two feet except where the cover crop grew to maturity.

CONCLUSIONS FROM 1941-42 STUDIES.

The first season's work led to the following conclusions:—

1. Neither a loose soil mulch nor a straw mulch was appreciably more effective in moisture retention than a bare, smooth surface.
2. Growing weeds or cover crop greatly increased moisture losses, especially in the early summer period.
3. The heavy lupin cover crop when allowed to mature drew moisture from the soil to a depth of approximately six feet.
4. In spite of all moisture conservation methods applied, the moisture loss from the 3-6 feet layer of this soil was considerable. (See Table 1, last column.) Additional losses occurred where a cover crop was allowed to grow to maturity after the winter rains had ceased.

1942-43 SEASON.

The treatments used in the second season were very similar to those in 1941-42, but weeds were eliminated by attention at more frequent intervals. This was done on B by cultivation with a three-pronged garden cultivator, on D and F by chipping with a spade, and on A, E and G by pulling or careful cutting without disturbing the surface soil. As A and E gave parallel results lupins and wild radish which germinated after rain on 20th December were allowed to grow on the E plots and their effect on moisture losses assessed. Instead of straw, a mulch of green lupin plants was used on G. These were put on 14th October, and because of their stage of maturity, dried out and left rather woody stalks for the mulch. By contrast, the lupins and radish cut on F on 24th August were so green and sappy that they rotted away and left very little residue. This was also noted in the previous season.

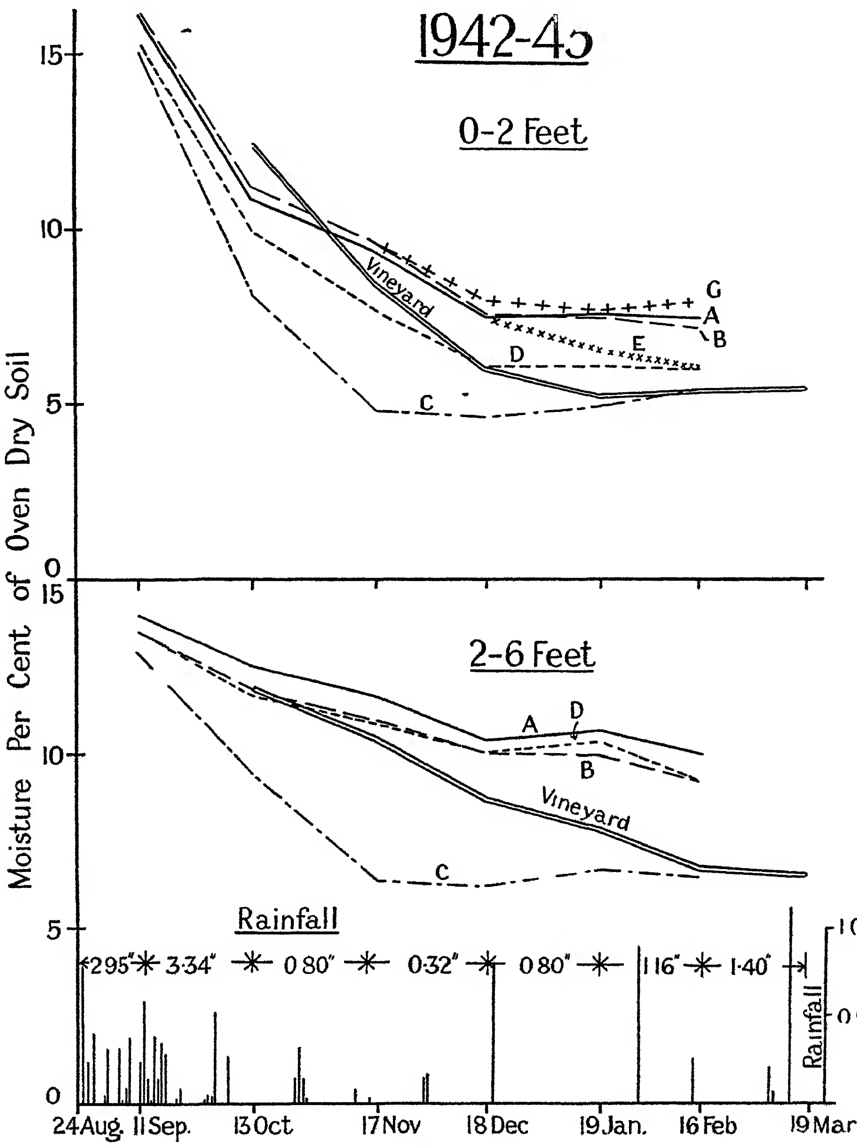

Fig. 2.

Soil moisture changes under various cultural and mulching treatments during spring and summer, 1942-43:—

A.—Cover crop dug in 24th August. Dug again 13th October. No later cultivations, but weeds carefully removed when B was cultivated.

B.—Cover crop dug in 24th August. Dug again 13th October. Cultivated 4th and 17th November, 21st December, 1st and 20th January, and 17th February.

C.—Uncultivated. Cover crop of lupins and radish grew to maturity.

D.—Cover crop removed 24th August Bare smooth uncultivated weed-free surface maintained.

E.—Cover crop removed and plots dug 24th August. Dug again 13th October. No later cultivations, but weeds removed till 20th December, *but not later.*

G.—Cover crop dug in 24th August. Dug again 13th October, when mulch of green lupin plants applied. Weeds under mulch periodically removed.

Vineyard.—Comparative data from vineyard on similar soil.

The moisture data and rainfall for this season are shown in Table 2 and on the graphs of Figure 2, where, to avoid confusion, only the data for A, B, C, D, and parts of E and G are illustrated. Because of the better weed control on the plots and the different character of the season's rain the different effects of the various treatments are, except for C, confined to the upper two feet of soil. The graphs of Figure 2 therefore give data for the layers 0-2 feet and 2-6 feet instead of 0-3 feet and 3-6 feet as in Figure 1. Table 2 is also presented in somewhat different form from Table 1 to better illustrate the data.

TABLE 2.

EFFECT OF VARIOUS CULTURAL AND MULCHING TREATMENTS ON SOIL MOISTURE LOSSES DURING SPRING AND SUMMER, 1942-43

(All figures are expressed as inches of rain.)

Treatment.	Net loss of Moisture, 11-9-42 to 18-12-42.			Further net Change, 18-12-42 to 16-2-43.			Net Loss 11-9-42 to 17-2-43.	Moisture in Soil, 17-2-43.
	0-2 ft	2-6 ft.	0-6 ft.	0-2 ft.	2-6 ft.	0-6 ft.	0-6 ft.	0-6 ft.
A. Cover crop dug in 24th August. Dug again 13th October. No later cultivations but weeds carefully removed when B was cultivated	2·87	2·36	5·23	*nil*	—0·27	—0·27	5·50	9·18
B. Cover crop dug in 24th August Dug again 13th October. Cultivated 4th and 17th November, 21st December, 1st and 20th January, and 17th February	2·88	2·34	5·22	—0·10	—0·54	—0·64	5·86	8·55
C. Uncultivated. Cover crop of lupins and radish grew to maturity	3·43	4·46	7·89	+0·23	+0·16	+0·39	7·50	6·10
D. Cover crop removed 24th August. Bare smooth uncultivated weed-free surface maintained	3·07	2·34	5·41	—0·03	—0·54	—0·57	5·98	8·11
E. Cover crop removed and plots dug 24th August. Dug again 13th October. No later cultivations but weeds removed till 20th December, but not later	2·75	2·34	5·09	—0·43	—0·50	—0·93	6·02	8·43
F. Cover crop cut and allowed to lie on surface. No cultivations, but weeds chipped as on D	3·27	2·12	5·39	+0·23	—0·38	—0·15	5·54	8·11
G. Cover crop dug in 24th August. Dug again 13th October, when mulch of green lupin plants applied. Weeds under mulch periodically removed	2·73	2·34	5·07	*nil*	—0·44	—0·44	5·51	8·84
Rainfall during same period ...	inches. .	inches. ..	inches. 4·46	inches.	inches. . .	inches. 1·96	inches. 6·42	inches ..
Data from four sites in similar soil among old Ohanez vines with roots going down at least 9 feet	Period 14th October to 18th December, 1942 2·13	2·07	4·20					
	Estimated Loss, 11th September to 18th December, 1942. 3·40	3·20	6·60	—0·20	—1·33	—1·53	8·13 (Estimated)	6·23

The spring and summer rainfall recorded at "Belvoir," about a mile from the experiment site, is set out hereunder:—

RAINFALL IN POINTS (100 POINTS = 1 INCH).

——	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total, 8 months.
1941-42 ...	375	339	218	105	8	*Nil*	18	200	1,263
1942-43 ...	627	357	165	11	112	90	26	173	1,561

The nature of each season is however, more clearly demonstrated by grouping the daily falls as follows:—

RAINFALL IN POINTS (100 POINTS = 1 INCH).

—	Aug. 1 to 19.	Aug. 20 to Oct. 7.	Oct. 8 to Nov. 13.	Nov. 14 to Dec. 19.	Dec. 20 to Feb. 25.	Feb. 26 to Mar. 18.
1941–42	280	641	20	104	Nil	140
1942–43	323	757	77	35	196	140

In each case there were generous late winter and spring rains up to 7th October. Thereafter both seasons were relatively dry up to 19th December. After that date the 1941-42 season was very dry till thunderstorms brought rain in late February and March, but in 1942-43 almost two inches of rain fell in the period 20th December to 25th February, and there were further thunderstorm rains in March.

Reference to Table 2 and the graphs of Figure 2 shows that considerable moisture losses occurred again in 1942-43 under all the treatments tested. The loss where the lupin and wild radish cover crop was allowed to grow on to maturity (C) is very striking. Although 3.34 inches of rain fell between 11th September and 13th October, there was a big net loss of moisture, indicating the terrific drain imposed by a heavy annual crop at an advanced stage of growth. Relatively dry weather in late September and a week of dry weather prior to 13th October caused losses in other treatments besides C, and a comparison of Figures 1 and 2 suggests that by mid-October the soils in general contained less moisture than at the same date in 1941. The great value of spring rains to the vineyard and orchard is apparent.

By 17th November the cover crop on C was practically mature and the soil moisture to six feet had been reduced to about 5 per cent. in the first two feet and 6.4 per cent. in the 2-6 feet layer. There had been a net loss equivalent to eight inches of rain.

The elimination of plant growth from all other treatments resulted in a saving of 2½ inches of rain by 18th December, and this saving was practically the same for all these treatments. The bare smooth surface of D showed a slight disadvantage which was probably due to the packing and partial sealing of the surface soil under the impact of grazing stock and the winter and spring rains. The D plots were under treatment C the previous season and in May, 1942, carried a good growth of lupins, radish, and grass. They were heavily grazed by cattle in June and the lupins badly trampled and mostly killed. As a result in August these plots had the poorest growth of herbage, while other plots previously neglected by the stock had much better growth.

On the F plots the cover crop, which had been cut on 24th August and allowed to lie on the surface, rotted and dried up to leave only a very small residue. By 18th December these plots had become practically the same as D plots where the surface was deliberately maintained smooth and bare.

After the fourth sampling on 18th December thunderstorm rains of 80 and 90 points were recorded on 21st December and 31st January. These offset evaporation losses to a large extent, but the cultivations given to B plots did not

conserve more moisture than A and D on which, however, weed growth was suppressed. On the E plots, which on the 18th December were comparable with A, B, and G, the lupins and radish germinated by the 20th December rain, were allowed to grow. On various plots of the five under this treatment sparse to moderate growth developed and the plants had reached a height of 6 to 15 inches by 17th February. This treatment showed a net loss of 0.43 inches of rain from the upper two feet between 18th December and 17th February, compared with 0-0.10 inches from A, B, D, and G.

The 0-2 feet section of Figure 2 shows that G maintained the highest moisture content in this layer after 13th October, the date on which the mulch of green lupin plants was spread on these plots. A study of the detailed sampling data shows that this advantage is confined to the 0-12in. layer and was approximately one per cent. compared with A. Since the graphs for A and G are more or less parallel on and after 13th October the result may be due to chance soil variations. It must be remembered, too, that the 100 pounds of green lupin plants spread on each plot contained about 85 pounds of water, which is equivalent to one per cent. of moisture in a foot of soil. The drying of the lupin plants would no doubt slow up the losses from the soil. In any case the effect of the litter mulch on G, even if real, is equivalent to only 16 points of rain and was achieved only by rigid elimination of any weeds which germinated under the mulch. Under these conditions it must be concluded that such a mulch would have no practical benefits in saving moisture.

It was noted that at the end of the 1941-42 season the surface soil of G under the straw mulch was much more mellow and friable than the soil of say, treatments A and E, and was, of course, in striking contrast to the caked surface of C, D, and F. The straw or similar mulch absorbs the energy of the raindrops—it takes the "sting" out of them before they hit the soil surface. In America this is considered to be an important effect in reducing soil erosion.

Assuming that the cover crop on C removed from the soil all the available water to a depth of six feet in October and November, 1942, it is seen from Table 2 that, in this type of soil, to a depth of six feet moisture equivalent to six inches of rain is unavailable for plant growth.

MOISTURE CHANGES IN VINEYARD.

During the 1942-43 season moisture studies were also made at four sites among old Ohanez vines in the "Belhus" vineyard. The soil was very similar to that of the experiment site discussed above and samples were taken on similar dates. The results are included in Table 2 and Figure 2. The first sampling was not made till 13th October, so that the losses from 11th September to 13th October have been estimated assuming that on the 11th September the moisture level in the vineyard was the same as under treatment A.

The gradual withdrawal of moisture by the vines throughout the six feet sampled is clearly seen. This contrasts with the rapid withdrawal of moisture by the quick growing, annual cover crop of lupins and wild radish. The flattening of the graphs in the late summer suggests that practically all the available moisture was removed, although the equivalent of about six inches of rain still remained Borings showed that these vines had roots going at least nine feet, and in late summer, apart from thunderstorms, these deep layers must be drawn on for moisture by old established vines.

CONCLUSIONS FROM 1942-43 STUDIES.

The second season's work amplified that of 1941-42, and showed that under conditions as at "Belhus":—

1. Given complete weed control in each case, neither a loose-soil mulch, constantly maintained by periodic cultivation, nor a mulch of plant material, applied at the rate of four tons of dry matter per acre, proved necessary to effect a maximum saving of soil moisture. An equal amount of soil moisture was retained over the summer months in plots which had only been twice dug, once in August and once in October, and the surface left in a rough condition.

2. The cover crop of New Zealand blue lupins and wild radish, when allowed to mature, drew moisture from the soil to a depth of about six feet and this loss occurred very largely from mid-September to mid-November. Under the grape vines the loss was more gradual and spread over a longer period.

3. Weed growth following on summer rains can cause substantial losses of moisture.

4. Plots which in neither season were dug over but had the cover crop cut (D and F) showed a greater net loss of moisture in spring and early summer than plots dug in August and October, apparently because the compact surface is less receptive to rain. However, plots dug over in spring showed no such effect even though several summer thunderstorms occurred.

Fig. 3.

Discing an annual cover crop in spring to leave much of the crop on the surface. This stops moisture losses through the growing crop and protects the soil from erosion and damage by late rains. A similar cultivation four to six weeks later will destroy weeds and further incorporate the cover crop with the surface soil.

[Reprinted from U.S.D.A. Farmer's Bulletin, No. 1917, 1942.]

PRACTICAL APPLICATIONS.

Since the loose soil mulch has, of itself, no virtue in soil moisture conservation, summer cultivation of orchards and vineyards will be of no benefit unless there are weeds to combat. Green manure and cover crops will cause very big moisture losses if they are not ploughed in by mid-September. In late August and early September these crops are, moreover, in excellent condition to rot in the soil when ploughed under, and the maximum benefit will follow.

The condition of the soil surface to receive and absorb rain is important, especially on sloping ground, if both runoff and soil erosion are to be reduced to a minimum. The impact of raindrops, especially in heavy showers, is an important factor in puddling the soil and sealing the surface. The pelting rain brings fine soil particles into suspension to be carried away as the water runs off the sealed surface. Considerable attention is now given in the United States of America to methods for keeping trash and crop residues on the surface to protect the soil and reduce erosion. For orchards, the dust mulch is right out of favour, and the discing of cover crops as shown in Figure 3 is recommended rather than a complete turning under. This guards against erosion losses while eliminating the cover crop as a competitor for moisture. Further cultivation later with a similar disc implement will control the majority of weeds and further incorporate the cover crop with the surface soil. A fine soil mulch need not be produced. Instead, quite a large proportion of the cover crop is left on the surface. In California this system of tillage is called "mulch tillage."

ACKNOWLEDGMENTS.

The authors are indebted to Mr. St. A. Barrett-Lennard for making available the experiment site at "Belhus," and materials to fence it; also for his keen interest in the results of the work. Mr. W. Jamieson and Mr. S. E. Bennett of the Horticultural Branch, also Messrs. F. V. Bridgman and G. J. Dwyer, rendered valuable assistance at various times with the digging and sampling of the plots.

Pedigree Seed.

It is anticipated that supplies of pedigree seed wheat, oats and barley will be available for distribution from the forthcoming harvest at the Research Stations.

Conditions of purchase will be the same as for last season, and farmers will be able to obtain their supplies either on a cash basis or in exchange for their own f.a.q. wheat delivered at the siding.

The rates of exchange and cash prices for wheat, oats and barley are:—

Exchange:

4½ bushels f.a.q. wheat* for 3 bushels pedigree seed wheat or barley.

3¾ bushels f.a.q. wheat* for 3 bushels pedigree seed oats.

* Or its equivalent in docked wheat.

Cash:

Wheat Belt Areas—

Wheat and barley—18s. per bag of 3 bushels.
Oats—13s. 6d. per bag of 3 bushels.

South-West Areas—

Wheat and barley—18s. per bag of 3 bushels.
Oats—15s. per bag of 3 bushels.

All of the above transactions are inclusive of rail freight to applicant's siding.

At present it is anticipated that seed of the following varieties will be available:—

Wheat: Late maturing—Febweb, Kondut.*
Mid-season maturing—Baroota Wonder, Bencubbin, Ford, Nabawa.
Early maturing—Gluyas Early, Koorda*, Merredin.
Very early maturing—Bungulla.
Premium varieties—Comeback, Pusa IV.

Oats: Late maturing—Algerian.
Mid-season maturing—Dale*, Guyra.
Early maturing—Ballidu*, Mulga.
Very early maturing—Wongan.

Barley: 2-row—Pryor.
6-row—Atlas.

Varieties marked with an asterisk are new productions of the Department, and were first made available for distribution for the current season's planting.

It is not intended that farmers should obtain their full supplies of seed from the Department but that by periodically buying small quantities of pedigree seed and growing their own stud seed plots, the quality of their seed will be maintained at a high level to their own benefit.

Also owing to only limited quantities of some varieties being available it is usually necessary to limit the number of bags of any one variety, and also may be necessary to limit the number of varieties per applicant. In view of this it will be of considerable assistance if applicants indicate their order of preference when making application.

When applying for seed, applicants should clearly state their full name and postal address, and also the *siding* to which they desire the seed railed.

Attention is drawn to the fact that though applicants are advised that their application has been recorded, no definite reservation can be made until after the receipt of the necessary warrant or cash remittance.

Prompt attention should therefore be given to all correspondence, particularly with regard to forwarding the warrant or cash remittance after receipt of the statement of account. The sheet of instructions accompanying these statements should be read carefully. Attention to these details will avoid disappointment.

All applications should be made *direct* to the Department of Agriculture, Perth, at an early date.

The Copper, Manganese, and Zinc Content of Subterranean Clover and Oats in Western Australia.

L. J. H. TEAKLE* and A. G. TURTON.†

SUMMARY.

A survey of the copper, manganese, and zinc content of subterranean clover, oats, wheat and barley representing soils over a considerable portion of the agricultural areas of the State is reported. These results may be considered in conjunction with experiments with plants and animals already reported in this and other Australian journals.

The results show that copper deficiency is general in certain districts of the State. Of these, Gingin, Dandaragan, South Busselton and the south coastal districts appear most severely affected.

Instances of copper deficiency are widely scattered over the whole of the agricultural areas investigated but are confined to certain soil types.

The better class soils, including loams and clay loams, are almost invariably well supplied with copper. Sandy loam soils are generally at least moderately well supplied with copper. In the majority of cases, copper deficiency is associated with sandy and gravelly soil types, but only certain classes of these soils appear to be low in available copper.

While there is experimental evidence of the occurrence of manganese deficiency with respect to a number of crops, this disorder does not appear to be general in Western Australia.

The analyses of subterranean clover and cereals indicate that zinc deficiency may occur on a number of light soil types in Western Australia. Further information regarding zinc deficiency will be necessary before any definite statement can be made.

The copper, manganese, and zinc deficiencies may be controlled by use of these substances in the fertiliser mixtures.

I. INTRODUCTION.

The correction of mineral deficiency of soils has played a large part in the establishment of agriculture in Western Australia. First and foremost is the need for generous fertilisation with phosphates. Nitrogen and potash are required under some circumstances by certain crops. Of recent years attention has been focussed on the micro-element deficiencies. Results from the use of these substances have been spectacular in many districts with certain soil types.

Cobalt.

Underwood and Filmer (1935, 1936) discovered that cobalt deficiency was the cause of *enzootic marasmus*, a wasting disease of cattle and sheep at Denmark. In Western Australia, administration of licks or drenches containing cobalt are effective controls and have become standard practice where the disease occurs. These treatments, together with the use of cobalt containing fertilisers, have been adopted as control measures in a number of parts of the world, notably New Zealand and Scotland.

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Cobalt deficiency is not known to affect plants, although the cobalt content of plant matter varies considerably according to the soil conditions.

Copper.

Much has been written on copper deficiency of crops in Western Australia. Wickens (1924) recognised exanthema of deciduous fruit trees and recommended the use of bluestone for its control. Pittman (1935) associated a mottle leaf condition of fig trees with copper deficiency, and some success in its cure has resulted from the application of bluestone to the soil. Dunne (1938) found copper treatment effective in the prevention of wither-tip of apples in Western Australia. Bennetts and Chapman (1937) established that copper deficiency was the primary factor in *enzootic ataxia,* a rickety type of disorder of lambs and sheep at Gingin, Dandaragan and Pardelup. This work has been extended to other districts and the results are discussed by Bennetts and Beck (1942). Another early symptom of copper deficiency in sheep is "stringy" wool. Bennetts (1942) has described this disorder and its distribution in Western Australia. Bennetts, Harley, and Evans (1942 (a) and (b)) have shown that "Falling Disease" of cattle in the Margaret River area is the fatal termination of acute copper deficiency. Further evidence of the unsatisfactory growth of crops, pastures and grape vines due to copper deficiency has been presented by the writers and their colleagues in many papers in this Journal.

In view of the occurrence of copper deficiency in many districts in Western Australia, particularly in agricultural industries of importance under war time needs, officers of the Department of Agriculture and the Government Chemical Laboratory have collaborated in a joint survey, the details of which are reported in this paper.

The prevention and cure of copper deficiency in crops is simple and cheap. Fertilisers containing copper as bluestone, copper ore, roaster residues and other substances in which the copper is more or less soluble, supply adequate quantities and result in the growth of normal crops.

Manganese.

Manganese deficiency of cereals was recognised by Carne (1927) at Dwarda and since then the disorder, often known as the "Grey Speck Disease" on account of the descriptive name given it by workers in Germany and Holland, has been identified on many areas in the Great Southern. Soil types most commonly affected are those associated with mallet hills. Teakle and Wild (1940) have described soil conditions associated with manganese deficiency of cereals. Manganese deficiency of certain vegetable crops occurs on calcareous soils, often swampy in nature, in the Albany and Perth metropolitan districts. Fruit trees, particularly apples, give evidence of manganese deficiency on gravelly soils in a number of parts of this State (Dunne, private communication).

Control is effected by the use of fertilisers containing manganese, generally in the form of crude manganese sulphate.

Zinc.

The results of the investigation of unthrifty growth of pines at Myalup (west of Harvey), Ludlow (near Busselton), at Margaret River and at Pardelup, have led to the diagnosis of zinc deficiency. Kessell and Stoate (1938) have described the spectacular responses of pines affected with this disorder to treatment with zinc and show that zinc sulphate sprays are very effective and cheap in promoting regeneration. Agricultural crops, however, have shown little evidence of zinc

deficiency in Western Australia. A chlorosis or mottle leaf of citrus has been cured by the administration of zinc as a spray or soil dressing, and recently, experiments with cereals at Dongara (Teakle, 1942) and with subterranean clover at Many Peaks (east of Albany) have shown that zinc and copper in combination are necessary for optimum results under certain soil conditions. There is also some evidence of response of subterranean clover to zinc-containing fertilisers at Mungedar, Dandaragan.

II. COPPER, MANGANESE, AND ZINC SURVEY OF CROPS.

The recognition of the occurrence of deficiencies of copper, manganese and zinc affecting crop growth as well as animal health in Western Australia has led to a considerable number of investigations. The present investigation was designed to obtain evidence regarding the location and possible extent of deficient areas.

A survey of the copper content of Western Australian pastures by Beck (1941) indicated the probable widespread occurrence of soil types subnormal in available copper status. Areas in which experiments with crops have shown response to copper-containing fertilisers have been mentioned by Teakle (1942). Figure 1 illustrates the pertinent information given in the sketch map incorporated in the 1942 paper showing centres at which copper deficiency has been demonstrated.

This work has been extended by a survey of the copper, manganese, and zinc content of subterranean clover, oats, and in some cases, wheat and barley, grown on a wide variety of soils representing a considerable portion of the agricultural areas of Western Australia. The sampling was carried out mainly in 1941 and 1942, but the records presented include a few samples from earlier work.

The first problem in this survey was the selection of suitable plants which from their chemical composition, would be useful indicators of the copper, manganese, and zinc status of the soil. Oats were selected as a probable indicator for the wheatbelt and subterranean clover for the wetter area. In view of the results of the investigations on the zinc composition of plants in Victoria, the oats were sampled in the early growth stage, generally from six to nine weeks after planting, and when the crop was six to eight inches tall. For convenience, subterranean clover was sampled in the middle of the flowering period, generally in October and early November, dependent on the earliness or lateness of the district. In some cases where wheat or barley was being used for experiments with copper-containing fertilisers, these crops were used as indicators instead of oats.

Oats appear satisfactory as a general indicator of copper deficient areas. Wheat and barley seem to behave similarly. Information presented below indicates that the copper content of the oats is low in deficient areas, and is much higher where availability of the copper is known to be satisfactory. While the evidence is scanty and not conclusive, it seems likely that oats will be useful as an indicator of the zinc status of soils. Results for manganese are quite indefinite.

The subterranean clover has proved to be a very valuable indicator plant. In this work, only the leaves, including the full petiole and leaflets, were taken in order to standardise sampling technique. The analysis of the leaves shows a remarkably good correlation between copper content and the known condition of the country with respect to copper. There is also good evidence that the zinc content of the leaves is a reliable indication of the zinc status. As with oats, the evidence with respect to manganese is indefinite.

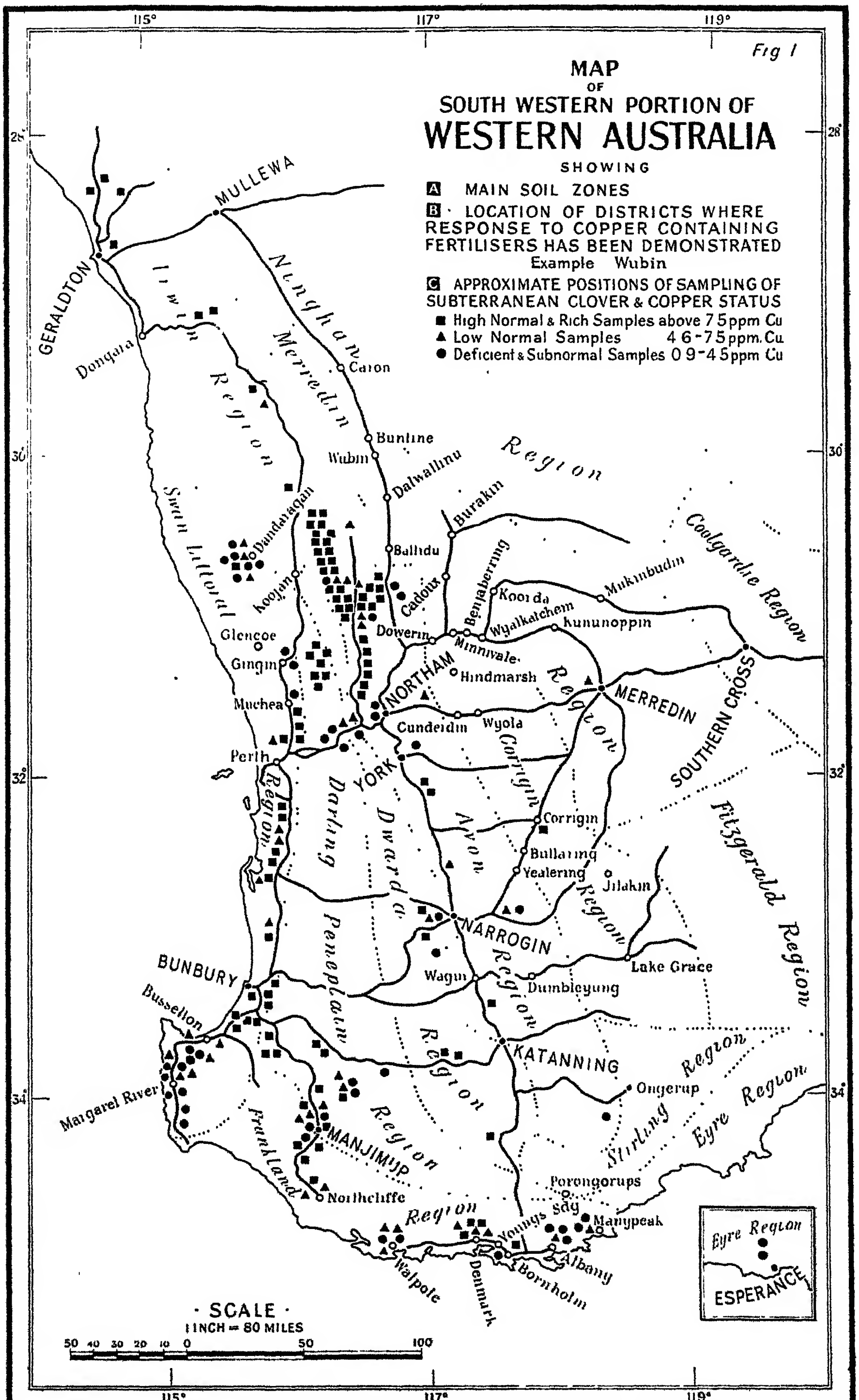
Fig 1
MAP
OF
SOUTH WESTERN PORTION OF
WESTERN AUSTRALIA
SHOWING
A MAIN SOIL ZONES
B · LOCATION OF DISTRICTS WHERE RESPONSE TO COPPER CONTAINING FERTILISERS HAS BEEN DEMONSTRATED
Example Wubin
C APPROXIMATE POSITIONS OF SAMPLING OF SUBTERRANEAN CLOVER & COPPER STATUS
■ High Normal & Rich Samples above 7 5ppm Cu
▲ Low Normal Samples 4 6-7 5ppm. Cu
● Deficient & Subnormal Samples 0 9-4 5ppm Cu
GERALDTON
MULLEWA
Irwin Region
Ninghan
Merredin
Region
Swan Littoral
Coolgardie Region
Fitzgerald Region
NORTHAM
YORK
MERREDIN
SOUTHERN CROSS
NARROGIN
KATANNING
MANJIMUP
BUNBURY
Perth
Darling
Dwarda
Peneplain
Region
Avon
Corrigin
Frankland
Stirling
Eyre Region
ESPERANCE
Albany
Denmark
Walpole
Northcliffe
Margaret River
Busselton
Porongorups
Manypeak
Lake Grace
Ongerup
Dumbleyung
Wagin
Jilakin
Yealering
Bullaring
Cundeidin
Wyola
Hindmarsh
Minnivale
Dowerin
Wyalkatchem
Kununoppin
Mukinbudin
Koorda
Benjaberring
Burakin
Dalwallinu
Wubin
Buntine
Caron
Ballidu
Cadoux
Dandaragan
Koojan
Glencoe
Gingin
Muchea
Dongara
Bornholm
SCALE
1 INCH = 80 MILES
50 40 30 20 10 0 50 100
115°
117°
119°
28°
30°
32°
34°

Subterranean clover is also of particular value in indicating the response to copper-containing fertilisers. Not only is the growth greatly improved on copper deficient soils, but the copper content of the leaves is greatly increased, and areas of subterranean clover pasture receiving copper fertilisers on copper deficient areas appear normal in copper content. The zinc content of subterranean clover leaves appears to be raised substantially by fertilisers containing zinc. On the other hand, oats were very disappointing from this viewpoint. While very great increase in growth occurred from the use of copper-containing fertilisers on copper deficient soils, the copper content of the oats was improved only to a very minor degree by the treatment.

In the course of this survey 202 samples of subterranean clover leaves and 56 samples of oats (including a number of wheat and barley samples) have been examined. Details of the analyses of the subterranean clover leaves are given in Appendix A, and of the oats, wheat, and barley in Appendix B.

In Appendix A the samples have been segregated according to the soil regions of the State as described by Teakle (1937). Briefly, the chief features of the regions from which samples have been obtained are as follows:—

1. *The Swan Littoral Region.*

The Swan Littoral Region extends as a narrow strip of country lying between the coast and the Darling Range, from Dandaragan in the north to Karridale in the south. The soils vary widely and include coastal sands, high quality alluvial soils and a variety of gravelly types. The chief timbers are jarrah, marri, and tuart. Three areas notable for copper deficiency of crops occur in this region. These are the Gingin and Dandaragan districts, where the soils are formed on Cretaceous rocks, and the South Busselton area, where the granites appear to be very deficient in minerals supplying copper.

2. *The Darling Peneplain Region.*

This region includes the plateau country of the Darling Ranges, extending from Wannamal in the north to Mt. Barker in the south. The soils are chiefly gravelly types, except where rivers have removed the laterite and exposed the country rocks as at Bridgetown, Balingup, etc. The timbers are chiefly jarrah and marri.

3. *The Frankland Region.*

The Frankland Region extends along the south coast from Hamelin Bay to Many Peaks, east of Albany. The chief timbers include karri, jarrah, and marri, and, while many of the soils resemble those of the Darling peneplain region, there are considerable areas of poorly drained soils, such as the kangaroo grass, bottle-brush, and blackboy flats.

4. *The Dwarda Region.*

The Dwarda Region extends as a narrow strip from Koojan in the north to Cranbrook in the south, and includes a range of sandy and gravelly soils associated with the wandoo (white gum) belt of the State.

5. *The Irwin Region.*

The Irwin Region extends from Ajana to Walebing and is characterised by the jam and York gum soils of the northern agricultural areas. It includes a large proportion of sandy and gravelly soils.

6. *The Avon Region.*

The Avon Region represents an extension of the Irwin Region and stretches from Walebing to Borden. In the southern portions, however, the soils are more gravelly and appear more highly leached. Besides jam and York gum, other timbers such as wandoo, morrel, and salmon gum are important in some districts.

7. *The Eyre Region.*

Principally sandplain country along the south coast from Many Peaks to Israelite Bay, east of Esperance.

8. *The Corrigin and Merredin Regions.*

Salmon gum, gimlet, morrel, and sandplain country, representative of the wheatbelt.

The analyses for copper, manganese, and zinc have been examined by means of distribution tables which have brought to light information which is deemed to be of fundamental importance. The results of this examination are given in Tables 1, 2, 3, 4, 5, and 6. In these distribution tables uniform intervals have not been used as a difference of, say, 1 p.p.m. is much more important in the lower ranges than in the higher ones. It was found that the use of intervals increasing successively by the factor 1.2 gave a reasonable number of ranges and placed the desired emphasis on small differences in the lower ranges.

As a graphic representation of the analytical results for subterranean clover, Figure 1 has been constructed to indicate the copper contents of samples obtained from various parts of the State.

For this purpose the samples have been segregated into three groups:—

(a) Deficient and subnormal—samples containing 0.9 to 4.5 p.p.m. of copper, indicated by the dots.

(b) Low normal—samples containing 4.6 to 7.5 p.p.m. of copper, indicated by the triangles.

(c) High normal and rich—samples containing more than 7.5 p.p.m. of copper, indicated by the squares.

Where too many samples had been obtained from one district to show each on the map without undue crowding—as at South Busselton—the position is represented by plotting half of the figures from each group.

The centres shown in small print on the map are districts in which copper deficiency of certain soils has been demonstrated by experiments. To indicate the main centres of the State, a few other towns at which no experimental work has given positive results have been plotted in block letters.

III. DISCUSSION.

(*a*) *Copper.*

The data are most extensive and particularly interesting with respect to copper, and a number of valuable points are brought out by the distribution tables 1 and 2.

(i) *Range in Copper Content.*—Both subterranean clover and oats show an extraordinary and similar range in copper content. For oats, the range is 0.9 to 20 p.p.m. and for subterranean clover 0.9 to 31.9 p.p.m. of copper in the dry material. This appears to be a very wide range in composition with respect to an element of vital importance in the crop growth. It may be interpreted to mean that, after meeting the relatively small fundamental needs of the plant, copper is accumulated and, where the soil conditions are suitable, luxury levels may be attained.

(ii) Consideration of the copper contents of subterranean clover and oats from areas where copper deficiency was known to exist shows a very close correlation between the copper content of the foliage and copper deficiency. For both subterranean clover and oats grown on copper deficient areas, over half of the samples contained less than 3 p.p.m. of copper.

It seems desirable that some explanation should be made with respect to the considerable number of samples of subterranean clover leaves from copper deficient farms in the South Busselton district which fall in the normal ranges—chiefly 4.7 to 8.4 p.p.m. of copper (Table 1). It is thought that many of these results are anomalous and not indicative of the fundamental copper status of the farms in question. Five of the 10 samples in the 4.7 to 8.4 ranges are from farms in which samples obtained previously from adjacent portions showed about 2 p.p.m. of copper. The soil conditions appeared similar and the subterranean clover had uniformly disappeared some years before due, perhaps to copper deficiency. The supposedly anomalous samples were obtained from control plots (receiving no copper as fertiliser) in experiments laid down in 1941 and designed to test the value of copper in various forms for the regeneration of a subterranean clover pasture, when resown with a generous quantity of seed. It seems possible that the intensive grazing of the experimental areas in the winter months has caused the effect of the copper fertiliser to be spread to the control plots and so raised the copper content of the newly established pastures.

The high copper samples from Dandaragan were taken from small patches at most a few square chains in extent, where subterranean clover had persisted for many years although it had failed generally in the rest of the paddocks. The patches were areas where seepage occurred and undoubtedly the soil is more generously supplied with available copper than is usual for the district. This information is of considerable interest in indicating the copper content of subterranean clover which has persisted for many years in an area where this species—prior to the introduction of copper fertilisers—has generally proved a failure.

(iii) Study of the distribution tables for copper indicate that the copper analyses group themselves into a number of subdivisions. Mention has already been made of the subdivision in which the samples contain from 1 to 3 p.p.m. of copper and which is characteristic of the most notable copper deficient areas. The rest of the samples ranging in copper content from 3 to 30 p.p.m. appear to include two main subdivisions. One from 3 to 7½ p.p.m. and the other above 7½ p.p.m. This segregation is not very apparent from the distribution table but the break between them is emphasised by further segregation of the samples in the 6.5 to 8.4 p.p.m range into smaller ranges as follows:—

Range.	6·5–6·9.	7·0–7·4.	7·5–7·9.	8·0–8·4.	Total.
No. of Samples	7	6	1	7	21

The paucity of samples in the 7.5 to 7.9 p.p.m. range supports this segregation. There seems every likelihood that these three subdivisions represent a fundamental characteristic of the Western Australian soil based on the nature of the underlying rocks which appear to fall into three main types according to copper status as follows:—

(a) Rocks very low in minerals supplying copper as occur in the South Busselton, Gingin and Dandaragan districts.

(b) Rocks generally of the granitic type moderately supplied with copper-supplying minerals.

(c) Rocks such as the better types of granites, dolerites, and basic schists which are well supplied with minerals from which are released adequate quantities of copper.

This grouping is more clearly indicated by the distribution table (Table 1) for subterranean clover than for oats (Table 2). It is possible that the oats would have shown a similar distribution had sufficient samples been taken and had the sampling been extended to cover all types of country with the object of obtaining a cross-section of the agricultural areas. In this work the oats were obtained largely from the lighter soil types.

From the nutritional point of view these subdivisions have been further divided into a number of groups which are proposed as a basis for judging the copper status of the soils with respect to plant nutrition. Using subterranean clover as the basis the proposed groups are:—

(1) Deficient—up to 3 p.p.m. of copper. In this group stalling of subterranean clover due to copper deficiency is likely and the stock will be unable to get adequate supplies of copper from the feed to maintain health.

(2) Subnormal—3.0 to 4.5 p.p.m. of copper. Subterranean clover may persist, if not thrive, but the copper intake for stock will be below that suggested as the lower limit by Beck (1941).

(3) Low normal—4.6 to 7.5 p.p.m. of copper. These represent soils formed on the more acidic types of granite rocks which cover a very considerable area of the State. Copper status is probably adequate for the normal growth of subterranean clover. Where the copper content is generally below 6 p.p.m. of copper the stock may not receive optimum copper requirements (Underwood private communication).

(4) High normal—7.5 to 15 p.p.m. of copper. Subterranean clover samples falling in this range represent growth on the stronger soils generally and where the parent rocks are more basic in character.

(5) Rich—above 15 p.p.m. of copper. Subterranean clover apparently has the capacity to absorb copper well beyond that actually needed for vigorous growth. Analyses above 15 p.p.m. are deemed to represent a luxury concentration of copper. It is possible that such high quantities of copper in the feed may not be to the advantage of certain classes of stock.

(iv) *Copper content of subterranean clover in relation to soil texture.*—From the distribution table (Table 1) evidence is presented regarding the analyses of subterranean clover on soils of different textures. This table indicates that it is very unusual for samples from loams to contain less than 7.5 p.p.m. of copper.

Practically all of the samples fall in the high normal and rich groups. The sandy loam soils exhibit a wider spread in the copper content of the subterranean clover. Generally, however, the samples from these soils show at least normal copper content. It is the sandy and gravelly soils which have produced the majority of the deficient and subnormal samples which contain less than 4.6 p.p.m. of copper. However, 61 per cent. of the samples on these soils contained at least normal amounts of copper. This lack of correlation between soil texture and copper content is disconcerting to the soil surveyor as it means that the wide range of soil types in Western Australia which fall in the sandy and gravelly categories cannot be judged for copper status on ordinary physical characteristics. It means that it will be necessary to study some other fundamental property and it is hoped that a determination of the heavy mineral content of these soils will give the key to the problem. By "heavy" mineral is meant a mineral heavier than quartz, such as hornblende, augite or epidote. These minerals commonly contain chemical elements of value in plant and animal nutrition.

Information regarding the analysis of clover from overseas sources is not very extensive. A selection of these has been summarised by Beeson (1941). The average of some 48 samples of red clover and alsike clover was 10 p.p.m. of copper with a range of 5 to 20 p.p.m. If we assume that subterranean clover leaves resemble red clover and alsike clover in copper content, this information indicates that the deficient and subnormal groups do not represent normal conditions in other countries. Western Australia is apparently unique in having such a wide variety of soils on which the clover exhibits copper concentration below 5 p.p.m.

(*b*) *Manganese.*

The data for manganese expressed in Tables 3 and 4 are inconclusive. It is known that manganese deficiency of cereals and fruit trees occurs in Western Australia, but no cases of clover being affected are known.

None of the samples obtained in this survey has been from areas on which manganese deficiency is known to exist. The range for analyses shown in Tables 3 and 4 is not suggestive of exceptionally low manganese status either for the oats or the clover. Unlike that for copper, it compares closely with the range given by Beeson (1941) for 86 samples of clover, including hop, alsike, crimson and red varieties which was 18.5 to 875 p.p.m. with an average of 145 p.p.m. of manganese. As with copper, many plants have the capacity to absorb large quantities of manganese when the conditions are conducive and it is thought that the high average given by Beeson reflects the effect of a considerable number of samples containing a luxury quantity of manganese.

(*c*) *Zinc.*

While a considerable amount of work with zinc deficiency has been carried out in Victoria, insufficient results have yet been published to establish the zinc content of deficient plants. In discussion with the Victorian workers it has been learned that, for cereals at least, it is necessary to obtain samples in the early growing period to get satisfactory results indicative of the zinc status of the soil. As the plant matures the differences observed in the early growth stages are eliminated and interpretation of analyses becomes difficult. In view of the recommendations of the Victorian workers an endeavour was made to obtain all samples of oats, wheat, or barley used in this investigation within six to eight weeks after planting. With respect to subterranean clover, as mentioned above, the samples were taken at the height of the flowering period. It was hoped that, as for copper, this growth stage would be suitable for work with zinc.

While it is not possible to lay down standards, it seems likely that the cereals at six to eight weeks from planting or the subterranean clover in the mid-flowering period should contain at least 20 p.p.m. of zinc to be regarded as normal. Analyses of subterranean clover from two areas where zinc deficiency has been established, suggests that the deficiency is more or less acute when the analyses are as low as 10 to 15 p.p.m. of zinc.

From the distribution tables (Tables 5 and 6) it seems that 13 per cent. of the samples of subterranean clover could be regarded as deficient and another 9 per cent. as subnormal, if not deficient. For oats, approximately 40 per cent. of the samples can be regarded either as deficient or subnormal. This conclusion is supported by the evidence presented by Beeson (1941). Forty-eight samples of alsike and red clover gave an average of 45 p.p.m. of zinc with a range of 24 to 70 p.p.m. Beeson's evidence with respect to cereals cannot be used as a basis for judging the results reported in this paper.

(d) *Foliar Diagnosis and Soil Mineralogy.*

The visual examination of soils having proved very uncertain as a means of detecting deficiencies it is necessary to resort to botanical, chemical, and mineralogical methods. Where the deficiencies are highly acute it is often possible to diagnose the trouble as a result of certain symptoms. However, many symptoms of nutritional disorders are not very definite and, generally, botanical characteristics are of limited value in the diagnosis of mineral deficiencies when not acute. Chemical examination of the foliage of oats and subterranean clover, or foliar diagnosis as it is commonly termed, has proved very satisfactory with respect to copper, and is promising for zinc. But the method is slow. It is necessary to wait for the crop to grow and it is possible that, with virgin country, the early analyses may be normal with respect to soils of low status until the small native resources of the soil are depleted and the deficiency manifests itself.

Of recent years the possibility of detection of the nutritional status of the soil from the actual mineral grains composing it has been investigated. There is evidence, at least with respect to copper and cobalt deficiency, that soils low in certain types of mineral grains are open to suspicion. As the mineralogical examination of the soil is quick and relatively simple in the hands of the experienced mineralogist, there is a prospect of this method being of considerable diagnostic value in the future judgment of soil fertility and in the recommendation of suitable fertiliser treatments to meet the requirements of the crop.

(e) *Correction of Mineral Deficiencies of Soils.*

The mineral deficiencies of soils under agricultural conditions are best corrected by means of appropriate fertilisers. Superphosphate has been adopted generally in Western Australia as a means of correcting the primary deficiency in phosphate. At little added expense, elements such as copper, manganese, and zinc can be added to the superphosphate and applied where evidence of deficiency of these elements has been obtained. Applications of copper as low as 5 lbs. of bluestone per acre have been known to remain active in the soil for several years, so that the expense involved in the use of copper as a fertiliser in Western Australia is very small.

Where stock deficiencies have become apparent, and it is not convenient or possible to use appropriate fertilisers, licks and drenches may be used as suggested by Bennetts and his colleagues in the veterinary services.

TABLE 1

COPPER CONTENT OF SUBTERRANEAN CLOVER LEAVES IN WESTERN AUSTRALIA ON LAND NOT FERTILISED WITH COPPER.

Distribution Table showing Percentage of Samples in each Range.

(A) For all samples. (B) On all farms on which copper deficiency has been demonstrated by experiments. (C) By soil regions. (D) By soil textures.

Samples.	Range of Copper Contents—p.p.m. Dry Material.										No. of Samples.
	Up to 2·0.	2·1–3·2.	3·3–4·6.	4·7–6·4.	6·5–8·4.	8·5–10·9.	11·0–13·9.	14·0–17·5.	17·6–21·8	Above 21·8.	
A. All Samples	5	11	13	16	11	12	14	7	7	4	203
B. (1) Samples from Farms on which Copper Deficiency has been demonstrated by Experiments	21	30	11	24	8	3	0	3	0	0	37
(2) Samples from other Farms	1	7	13	15	11	14	17	8	9	5	166
C. Soil Regions—											
(1) Swan Littoral Region	13	14	9	20	11	8	9	8	6	2	64
Dandaragan and Gingin Districts	17	33	17	17	8	0	0	8	0	0	12
South Busselton District	24	20	8	28	12	4	4	0	0	0	25
(2) Darling Peneplain Region	3	20	7	10	13	14	13	3	7	10	30
(3) Frankland Region (South Coast)	0	15	22	26	19	11	7	0	0	0	27
(4) Dwarda Region	0	8	23	23	8	23	15	0	0	0	13
(5) Irwin Region	0	0	0	9	0	9	41	9	18	14	22
(6) Avon Region	2	2	21	12	7	14	9	16	14	3	43
(7) Corrigin and Merredin Regions	0	0	0	0	50	50	0	0	0	0	2
(8) Eyre Region (Esperance)	0	100	0	0	0	0	0	0	0	0	2
D. Soil Texture—											
(1) Loams	0	3	0	6	6	18	24	16	18	9	33
(2) Sandy loams	2	5	9	19	16	9	19	7	7	7	43
(3) Sands, loamy sands, and gravelly sandy soils	7	16	18	18	8	11	10	5	5	2	119

Interval increases in geometric progression—Factor × 1·2.

TABLE 2.

COPPER CONTENTS OF SAMPLES OF OATS, WHEAT, AND BARLEY.

Distribution Table showing Percentage of Samples in each Range.

Foliage Sampled 6 to 9 weeks after Planting and Grown without Copper Fertiliser on Properties representing generally the Lighter types of Soil in the Wheat and Contiguous Districts of Western Australia.

Samples.	Range of Copper Contents—p.p.m. Dry Material.									No. of Samples.
	1·0–2·0.	2·1–3·2.	3·3–4·6.	4·7–6·4.	6·5–8·4.	8·5–10·9.	11·0–13·9.	14·0–17·5.	Above 17·5.	
All Samples	11	11	23	18	12	12	11	0	2	56
Farms where copper deficiency is not established	0	5	22	20	18	18	15	0	2	40
From copper deficient farms	38	25	25	12	0	0	0	0	0	16
From Dandaragan	75	13	12	0	0	0	0	0	0	8

Interval increases in geometric progression—Factor × 1·2.

TABLE 3.

MANGANESE CONTENT OF SUBTERRANEAN CLOVER LEAVES ON WESTERN AUSTRALIAN SOILS.

Distribution Table showing Percentage of Samples in each Range.

Samples.	Range of Manganese Contents—p.p.m. Dry Material.									No. of Samples.
	21–32.	33–46.	47–64.	65–84.	85–109.	110–139.	140–175.	176–218.	Above 218.	
All samples	3	17	18	19	17	10	9	5	2	93

Interval increases in geometric progression—Factor × 1·2.

TABLE 4.

MANGANESE CONTENTS OF SAMPLES OF OATS, WHEAT, AND BARLEY.

Distribution Table showing Percentage of Samples in each Range.

Foliage Sampled 6 to 9 weeks after Planting and Grown without Manganese Fertiliser on Properties representing generally the Lighter types of Soil in the Wheat and Contiguous Districts of Western Australia.

Samples.	Range of Manganese Contents—p.p.m. Dry Material.									No. of Samples.
	20–32.	33–46.	47–64.	65–84.	85–109.	110–139.	140–175.	176–230.	Above 230.	
All samples	6	3	9	18	25	9	12	3	15	33

Interval increases in geometric progression—Factor × 1·2.

TABLE 5.

ZINC CONTENT OF SUBTERRANEAN CLOVER LEAVES ON WESTERN AUSTRALIAN SOILS NOT FERTILISED WITH ZINC.

Distribution Table showing Percentage of Samples in each Range.

Samples.	Range of Zinc Contents—p.p.m. Dry Material.									No. of Samples.
	10–16.	17–21.	22–27.	28–34.	35–42.	43–52.	53–64.	65–78.	79–95.	
All samples	14	9	24	13	23	9	3	4	1	76

Interval increases in geometric progression—Factor × 1·2.

TABLE 6.

ZINC CONTENTS OF SAMPLES OF OATS, WHEAT, AND BARLEY.

Distribution Table showing Percentage of Samples in each Range.

Foliage Sampled 6 to 9 weeks after Planting and Grown without Zinc Fertiliser on Properties representing generally the Lighter types of Soil in the Wheat and Contiguous Districts of Western Australia.

Samples.	Range of Zinc Contents—p.p.m Dry Material.					No. of Samples.
	13–18.	19–26.	27–34.	35–44.	45–56.	
All samples	37	29	14	9	11	35

Interval increases in geometric progression—Factor × 1·2.

APPENDIX A.

COPPER, MANGANESE, AND ZINC CONTENTS OF SUBTERRANEAN CLOVER LEAVES AND PETIOLES SAMPLED IN OCTOBER AND NOVEMBER WHEN PLANTS IN FULL FLOWERING.

Standards of Copper Status

1. Deficient—up to 3·0 p.p.m.
2. Subnormal—3·1 to 4·5 p.p.m.
3. Low normal—4·6 to 7·5 p.p.m.
4. High normal—7·6 to 15·0 p.p.m.
5. Rich—above 15·0 p.p.m.

SWAN LITTORAL REGION.

Sample Number.	Name of Farmer.	District.	Type of Country.	p.p.m. Dry Basis. Cu.	Mn.	Zn.	Copper Status.
....	Brown†	Dandaragan	Grey brown diatomaceous loam—bluegum	2·6	....	..	Deficient
119	Brown†	Dandaragan	Reddish loose sandy soil—marri, banksia	2·2	....	..	Deficient
120	Brown†	Dandaragan	Dark brown loamy sand—Yorkgum, marri	1·8	....	..	Deficient
121	Brown†	Dandaragan	Dark brown loamy sand—Yorkgum	6·1	....	.	Low normal
122	Yathroo†	Dandaragan	Sandy soil—bluegum	4·3	92	13	Subnormal
123	Yathroo†	Dandaragan	Dark chocolate brown loamy sand—marri and bluegum	1·3	..	..	Deficient
124	Yathroo†	Dandaragan	Brown sand, clay subsoil—bluegum	16·2	..	..	Rich
125	Yathroo†	Dandaragan	Dark grey loamy sand—bluegum	2 3	53	55	Deficient
126	Yaodabbie†	Dandaragan	Brown sand on red with gravel—marri and banksia	4·6	....	....	Low normal
127	Yaodabbie†	Dandaragan	Sand soak land	7·3	..	....	Low normal
128	Mungedar*	Dandaragan	Brown sand—marri	16·1	51	22	Copper treated
129	Mungedar*	Dandaragan	Brown sand on red sand—marri and wattle	12·5	97	10	Copper treated
130	Mungedar*	Dandaragan	Brown sand on red sand—marri and wattle	5·4	85	32	Copper treated, zinc treated
131	Mungedar*	Dandaragan	Black brown loam on yellow brown clay at 5 inches	6 5	38	21	Copper treated
132	Mungedar*	Dandaragan	Black brown loam on yellow brown clay at 5 inches	5·4	36	33	Copper treated, zinc treated
71	Locke*	Muchea	Grey sand, cement subsoil—wattle, bluegum and blackboy	7·9	....	..	Copper treated
90	Fewster, A.	Muchea	Grey brown gritty sand—jarrah, marri	3·8	....	..	Subnormal
209	Rennie†	Gingin	Reddish brown sand—marri and banksia	2·2	43	12	Deficient
211	Rennie†	Gingin	Red loamy sand and gravel—marri	5·1	..	..	Low normal
213	Edgar*	"Glencoe," Gingin	Brown red sand—marri, banksia, and scrub	6·7	..	..	Copper treated
89	Woodsome Estate—Copley	Bullsbrook	Yellowish brown sandy loam—marri and wandoo	8·2	....	..	High normal
214	Copley's Bank	Upper Swan	Brown sandy loam—marri and bluegum	23·0	298	41	Rich
215	Copley's Bank	Upper Swan	Brown sand, loose—marri	20·7	....	....	Rich
208	Marshall	West Swan	Grey yellow sand—paper bark, jarrah, marri	15·1	81	46	High normal
221	Marshall	West Swan	Grey sandy soil—jarrah, marri, paperbark	5·5	79	39	Low normal
49	French	Byford	Brownish yellow gravelly sand—stunted jarrah and sheoak	12·2	88	45	High normal
50	Elliott	Serpentine	Brown loam, alluvial—marri flat	10·8	99	61	High normal
51	Middleton	Keysbrook	Gravelly soil, yellow clay subsoil—stunted jarrah	6·2	...	...	Low normal

Beck 523	....	Keysbrook	Sampled 1939	7·3	..	..	Low normal
52	45·8 miles	North Dandalup	Grey sand on yellow gravelly—sandy clay loam—stunted jarrah and marri	4·6	....	....	Low normal
53	McEncroe	North Dandalup	Grey brown sandy loam—bluegum	13·3	.	..	High normal
54	Smith	Coolup	Grey sandy rise	6·1		..	Low normal
55	Trickett	Coolup	Orange to yellow brown sand—jarrah and scrub	10·8	.	..	High normal
56	Flax Factory	Yarloop	Grey sandy loam—wandoo	7·4	128	40	Low normal
37/40	Hanks	Harvey	Brown loam—marri	16·1	62	..	Rich
57	Stone Bros.	Brunswick	Brown fine sandy loam—wandoo	13·7	206	45	High normal
207	Shine	Brunswick	Grey loamy sand on yellow clay—marri and bluegum	13·5	...	.	High normal
58	McLeod	Waterloo	Chocolate sandy loam on redgum bank	17·9	57	37	Rich
59	Craig	Dardanup	Chocolate clay loam—bluegum	16·6	73	42	Rich
60	Buckenarra	Crooked Brook	Yellowish grey sandy soil—marri flat	13·6	..	..	High normal
204	Abel	Boyanup	Rich brown sandy loam—bluegum and marri	17·1	..	..	Rich
61	Boyanup-Elgin	Road	Grey sandy soil—jarrah, marri	9·7	161	44	High normal
62	Scott	Statham	Bluegum, marri flat	10·9	..	..	Hogh normal
38/40	Roberts	Capel	Chocolate clay loam (1940)	17·9	106	..	Rich
63	Roberts	Capel	Bluegum flat (1941)	20·0	..	..	Rich
192	Hutton	Capel	Grey sand (wet)—marri, jarrah, Christmas tree	5 3	134	35	Low normal
64	Plaistowe	Abba River	Grey sandy soil—jarrah, marri	4·7	..	..	Low normal
186	Dawson	Vasse	Grey sand—peppermint, paperbark, marri	6·0	....	...	Low normal
29	Bell†	Vasse	Reddish powdery sandy soil—marri	1·5	....	..	Deficient
31	Bell†	Vasse	Reddish powdery sandy soil—marri	2·0	..	..	Deficient
22/40	Radford Park† (Loc. 2396)	Vasse	Grey sandy soil—jarrah:— 1940 Experiments—1940	1·1	60	..	Deficient
23	Radford Park† (Loc. 2396)	Vasse	1941	2·6	86	40	Deficient
25	Radford Park† (Loc. 2396)	Vasse	1941 Experiments— (a)	6·2	.	..	Low normal
27	Radford Park† (Loc. 2396)	Vasse	(b)	8·9	....	....	High normal
20	Moylan† (Loc. 2391)	Kaloorup	Powdery red sandy soil—jarrah— (a)	3·2	49	40	Subnormal
21	Moylan† (Loc. 2391)	Kaloorup	(b)	2·4	...		Deficient
Beck 330	....	Yelverton	Sampled 1938	8 0	..	..	High normal
34	Briggs	Metricup	Brown sandy loam—marri	12·0	37	37	High normal
Beck 343	....	Metricup	Sampled 1938	5·1	....	..	Low normal
31/40	Wilkinson†	Metricup	Greyish gravelly loamy sand—jarrah—1940	2·2	66	..	Deficient
35	Wilkinson†	Metricup	1941	5·4	..	.	Low normal
37	Wilkinson†	Metricup	Greyish gravelly loamy sand—jarrah	8·3	60	27	High normal
40	Wilkinson†	Metricup	Greyish gravelly loamy sand—jarrah	5·1	..	.	Low normal
42	Blaikie†	Cowaramup	Brown grey sand—jarrah	5·8	77	68	Low normal
....	Rapson† (Loc. 2088)	Cowaramup	Brown grey sand—jarrah	1·8	46	..	Deficient
25/40	Smith†	Bramley	Grey sand—jarrah and marri. Sampled 1940	2·7	77	.	Deficient
46	Smith†	Bramley	Control plot (1941) experiment. Sampled 1941	6·5	69	69	Low normal
45	Cooper	Margaret River	Yellow grey gravelly sand—jarrah and marri	4·4	..	....	Subnormal
Beck 476	†	Margaret River	Sampled 1939	1·2	....	....	Deficient
44	Wright*	Witchcliffe	Gravelly country—jarrah, marri	12·5	....	..	Copper treated
48	Pearson	Forest Grove	Brownish grey sandy soil—marri and karri	4·1	108	80	Subnormal
35/40	Millar†	Forest Grove	Brown sandy loam—karri and marri (1940)	1 0	41	..	Deficient

DARLING PENEPLAIN REGION.

91	Hart, E.	South Chittering	Red gravelly loam—wandoo	9·5	...	.	High normal
92	Hart, G.	South Chittering	Red loam with basic schist—marri	11·5	151	33	High normal
93	Payne	Chittering	Red loam—marri and wandoo	13·2	....	....	High normal

* Land treated with copper-containing fertilisers.

† Farms on which copper deficiency has been demonstrated by experiments.

APPENDIX A—continued.

Sample Number.	Name of Farmer.	District.	Type of Country.	p.p.m. Dry Basis. Cu.	Mn.	Zn.	Copper Status.
			DARLING PENEPLAIN REGION—*continued*.				
94	Payne	Bindoon	Red loam—wandoo	20·1	..	..	Rich
95	Stephens	Bindoon	Red gravelly loam—marri	21·3	76	28	Rich
96	Stephens	Bindoon	Brown loam, alluvial—marri	22·0	..	..	Rich
97	Christian Bros.	Bindoon	Red loam—Yorkgum and wandoo	24·8	..	..	Rich
66	Sanatorium	Wooroloo	Yellow brown gravelly sand	2·1	36	14	Deficient
150	Sanatorium	Wooroloo	Brown grey gravelly sand—jarrah, casuarina	2·5	..	..	Deficient
151	Sanatorium	Wooroloo	Yellow grey gravelly loamy sand—jarrah and marri	0·9	58	13	Deficient
152	Sanatorium	Wooroloo	Green clover—grey gravelly loamy sand	2·6	..	..	Deficient
153	Sanatorium	Wooroloo	Yellow clover—grey gravelly loamy sand	2·1	..	..	Deficient
193	Fry	Donnybrook	Grey chocolate loam—phalaris good	12·6	129	31	High normal
194	Wright	Kirup	Brown loam of marri hill type	31·9	85	65	Rich
195	Wright	Kirup	Red brown loam and stones—marri	11·9	..	..	High normal
36/40	..	Bridgetown	Red loam—marri	15·8	49	..	Rich
202	Cuming	Mayanup	Grey sandy granitic soil—marri, jarrah	8·2	..	..	High normal
203	Cuming	Mayanup	Grey gritty sandy loam—jarrah, blackboy, wandoo	5·2	..	..	Low normal
9	Farleigh	Mayanup	Lateritic soil—jarrah, marri, blackboy	3·2	27	49	Subnormal
Beck 497	Forrest	Mayanup	Gravelly soil—jarrah. Sampled 1939	4·3	..	..	Subnormal
12	Forrest	Mayanup	Medium dark loam—redgum and blackboy	4·8	..	..	Low normal
205	..	Wilga	Grey sandy loam on gravel subsoil—tall jarrah and marri	8·9	..	..	High normal
206	..	Wilga	Grey sandy loam, gravel subsoil—bluegum, marri, paperbark	7·3	..	..	Low normal
201	Morgan	Dingup	Dark chocolate loam—marri, blackbutt, jarrah	9·2	..	..	High normal
196	Shepherd	Manjimup	Brownish gravelly soil—jarrah, marri	3·8	..	..	Subnormal
197	Shepherd	Manjimup	Brownish gravelly soil—jarrah, marri—west paddock	6·6	..	..	Low normal
17/40	Hall	Yanmah	Gravelly sand—jarrah	10·8	66	..	High normal
199	Hall	Yanmah	Gravelly sandy loam—jarrah, marri	6·9	..	..	Low normal
86	Hall	Yanmah	Gravelly sandy loam—jarrah and marri	3·2	66	16	Subnormal
198	Runge	Yanmah	Brown sandy soil—jarrah and marri	4·7	..	..	Low normal
233	Pardelup Prison Farm*	Mt. Barker	Grey sandy loam—jarrah and marri	9·2	71	23	Copper treated
234	Pardelup Prison Farm*	Mt. Barker	Grey gritty soil—jarrah and marri	15·2	..	..	Copper treated
			FRANKLAND REGION.				
200	Emery	Middlesex	Red loam—karri, marri	12·8	45	37	High normal
85	Doyle	Jardee	High level karri and marri country—brown sandy loam	3·8	82	22	Subnormal
247	Angel	Jardee	Brown sandy loam—karri	8·4	47	26	High normal
250	Hunter	Pemberton	Reddish brown sandy loam—karri	8·8	33	31	High normal
1/40	McRitchie	Northcliffe	Brown yellow gravelly sand—jarrah, karri	6·6	94	..	Low normal
18/40	Willis	Northcliffe	Grey and brown sand—(a)	8·4	48	..	High normal
14/40	Willis	Northcliffe	(b)	5·5	36	..	Low normal
72	Jordan	South Napier	Sandy soil—jarrah and marri	4·3	..	..	Subnormal
73	Jordan	South Napier	Poor grey sandy slope	4·4	..	..	Subnormal
74	Jordan	South Napier	Grey sandy soil	5·0	76	27	Low normal
75	Manton	South Napier	Gravelly sandy loam on yellow clay	2·9	..	..	Deficient
241	Norman†	Many Peaks, Albany	Brown clay loam on marl—yate and marri	4·9	63	16	Low normal
245	Norman†	Many Peaks, Albany	Grey sandy loam on marl—marri	4·3	..	..	Subnormal
80	Norman†	Many Peaks, Albany	Brown sandy loam—marri, yate	2·5	..	..	Deficient
76	Research Station	Denmark	Brown loam—karri	4·9	39	22	Low normal

77	Research Station	Denmark	Grey sandy country—karri—good subterranean clover	8·1	30	26	High normal
78	Tame (Loc. 412)	Denmark	Brown loamy soil—good karri country	11·3			High normal
79	Hard (Loc. 2010)	Denmark	Clay flat—tall subterranean clover growing in bracken	9·1			High normal
81	Smith (Loc. 551)	Mt. Shadforth	Brown Wakundup soil—karri	5·3	38	26	Low normal
83	Gardner	Shadforth Road		7·0	77	27	Low normal
82	Daly	Young's Siding	Grey brown sandy loam—paperbark, kingia, and scrub flat	2·5	105		Deficient
84	Knapp	Torbay	...	10·5			High normal
20/40	Steele†	Walpole	Greyish yellow brown, very gravelly loamy sand—(a)	3·1	35		Subnormal
13/40	Steele†	Walpole	Greyish yellow brown, very gravelly loamy sand—(b) Sampled 1940	6·3	26		Low normal
229	Steele†	Walpole	Greyish gravelly loamy sand—karri, tingle and wattle. Sampled 1942	4·8			Low normal
230	Hatfield	Walpole	Gravelly slope—karri, jarrah, marri	3·8			Subnormal
231	Cooper*	Walpole	Grey gravelly soil—marri, karri	14·8			Copper treated
232	Cooper†	Walpole	Grey gravelly soil—marri, karri	1·6			Low normal
			DWARDA REGION.				
67	Trott	Baker's Hill	Grey granitic soil, some ironstone gravel—wandoo and jam— (a) Dwalganup strain	3·0	52	18	Deficient
68	Trott	Baker's Hill	(b) Midseason strain	5·0			Low normal
148	Tognolini	Baker's Hill	Grey to brown-yellow gravelly sandy loam on yellow subsoil—wandoo	6·9			Low normal
149	Tognolini	Koojedda	Brown-grey sandy loam—wandoo and marri	5·4			Low normal
164	102-mile Peg	Williams	Gritty loamy sand—York and floodgum, jam	11·9			High normal
165	128-mile Peg	Albany Road	Gravelly loamy sand—jarrah, wandoo, parrot bush	3·5			Subnormal
166	Fowling	Congeling	Gravelly loamy sand—jam, wandoo, sheoak	12·9			High normal
167	Kojonup Road	Boyup Brook	Loamy sand—jarrah, marri, blackboy	3·7			Subnormal
5	Narrogin School of Agriculture	Narrogin	Sandy loam—marri, floodgum, Yorkgum	4·1	102	36	Subnormal
10	Higham	Narrogin	Sandy loam—jam, sheoak, wandoo	4·8	112	18	Low normal
6	Partridge	Kojonup	Loam—jam, wandoo, floodgum	10·7	63	35	High normal
7	Warren Bros.	Kojonup	Light sandy loam—jam, wandoo, floodgum	10·5	100	26	High normal
11	Walters	Cranbrook	Heavy clay loam—jarrah, wandoo, blackboy	9·0	53	17	High normal
			IRWIN REGION.				
160	Husband	Northampton	Brown loamy sand—jam	12·9			High normal
15	Teakle	Isseka	Red-brown sandy loam—jam country	18·6	177	40	Rich
16	Chapman Research Station	Nabawa	Red-brown sandy loam—jam country	11·8	174	28	High normal
158	Preston Bros.	Moonyoonooka	Loam—jam and wattle	13·2			High normal
13	Wells	Mingenew	Brown sandy loam—jam and Yorkgum	13·5	177	43	High normal
14	Wells	Mingenew	Yellowish-grey sandplain	9·8			High normal
87	Williamson	Three Springs	Dark brown clay loam	14·0	86	27	High normal
159	Chappell	Winchester	Loam—salmon gum	5·9			Low normal
161	Elliott	Watheroo	Salmon gum and wandoo	12·2			High normal
8	Seymour	Miling	Red-brown sandy loam—Yorkgum and jam	5·1	212	27	Low normal
113	Kelsall	Berkshire Valley	Light brown gritty sand—jam	12·7	246	24	High normal
114	Kelsall	Berkshire Valley	Brown sandy loam to sandy clay loam—Yorkgum, salmongum	22·2			Rich
115	Kelsall	Berkshire Valley	Light brown to brown loamy sand—jam and sheoak	21·3			Rich
116	Kelsall	Berkshire Valley	Rich brown heavy loam dolerite—Yorkgum	19·0	110	34	Rich
117	Kelsall	Berkshire Valley	Brown loamy sand, granitic—jam	24·4	...		Rich
118	Kelsall	Berkshire Valley (Prye)	Sand—wandoo and scrub to poor jam	11·7			High normal
112	Sandland	Walebing	Red brown loamy sand—jam	18·4			Rich

* Land treated with copper-containing fertilisers.

† Farms on which copper deficiency has been demonstrated by experiments

APPENDIX A—continued.

Sample Number.	Name of Farmer.	District.	Type of Country.	.m. Dry Basis. Cu.	Mn.	Zn.	Copper Status
			IRWIN REGION—*continued.*				
111	Lefroy	Walebing	Rich red brown sandy loam, dolerite—jam and Yorkgum .. .	17·1	124	38	Rich
109	Cross	0·9 miles south of Walebing	Yellow grey gravelly sand—wandoo, jam	9·4	134	16	High normal
110	Cross	Walebing	Yellow brown gravelly loamy sand—wandoo and scrub . .	13·8	46	20	High normal
133	Cross	Walebing	Brown gravelly sandy loam on red clay subsoil, dolerite outcrops—wandoo	30·2	....	....	Rich
134	Cross	Walebing	Yellow grey sand, some gravel, granite outcrops—wandoo and scrub	11·4	.. .	..	High normal
			AVON REGION.				
98	Moore	New Norcia	Yellow brown fine gravel, sandy loam, reddish clay subsoil—marri	13·9	.. .	....	High normal
99	Clune	New Norcia	Brown loamy coarse sand—Yorkgum and marri	16·1	....	....	Rich
100	Clune	New Norcia	Brown loamy coarse sand—Yorkgum and marri	16·6	179	30	Rich
101	Clune	New Norcia	Brown gritty loam, dolerite outcrops—Yorkgum	14·9	77	32	High normal
102	Clune	New Norcia	Dark brown loam—floodgum	20·4	. .	.. .	Rich
103	Benedictine Community	New Norcia	Brown loamy sand—jam	20·0	....	...	Rich
104	Edgar	New Norcia	Brown loamy sand—jam and Yorkgum	14·8	....	....	High normal
105	Edgar	New Norcia	Yellow brown sand—wandoo, stinkwood, tamma . .	7·2	.. .	...	Low normal
106	Saleeba	Waddington	Brown gravelly loamy soil—wandoo, Yorkgum	4·2	.. .	.	Subnormal
107	Saleeba	Waddington	Brown gritty loamy sand—jam	14 3	....	....	High normal
108	Essex	Waddington	Light brown gritty loamy sand—jam and Yorkgum	18·7	. ..	. .	Rich
135	Kennedy	Piawaning	Light yellow brown sand, some gravel—wandoo and scrub ...	6·2	....	.	Low normal
136	Duggan, J. J.	Yericoin	gravelly heath country	5·8	174	20	Low normal
137	Duggan, J. J.	Yericoin	Light brown loam—salmongum	18·8	. ..	..	Rich
138	Duggan, J. J.	Yericoin	Brown sandy loam—morrel and salmongum	16·3	64	28	Rich
139	Duggan, A. R.	Yericoin	Greyish yellow sand, some gravel—wandoo, tamma	16·9	....	...	Rich
140	Duggan, T. P. W.	Yericoin	Very gravelly sand—wandoo, parrot bush	7·8	....	. ..	High normal
156	Paddison	Yericoin	Gritty gravelly sand—wandoo	4·6	....	. .	Low normal
157	Paddison	Yericoin	Deep loose grey sand—tussock grass and scrub	3·0	.. .	....	Deficient
141	Halse	Calingiri	Yellow brown gravelly sand—wandoo, jam, and scrub .	5·3	...	.. .	Low normal
142	Lindsay	Calcarra	Brown grey gritty sand near salty creek	8·8	. .	..	High normal
143	Phillips	Culham	Dark brown loamy sand, clay sub-granitic and dolerite boulders	13·3	173	31	High normal
144	Phillips	Culham	Dark brown loamy sand on yellow clay—jam and Yorkgum	18·6	.. .	.. .	Rich
145	Phillips	Coondle	Dark brown to red brown loamy sand on yellow stony clay—granitic	22·8	..	. ..	Rich
146	Groves	Toodyay	Grey brown heavy sandy loam, slightly moist	17·8	.. .	..	Rich
147	Groves	Toodyay	Brown loamy sand, brown gritty clay at 12 inches—jam	9·3	150	13	High normal
154	Ackland	Wongan Hills	Brown grey gritty loamy sand—tamma, scrub	9·5	....	. .	High normal
155	Ackland	Wongan Hills	Brown grey gritty loamy sand—tamma, scrub	10·2	94	21	High normal
69	Wongan Hills Research Station	Wongan Hills	Gritty sandy soil, scrub plain	3·9	90	24	Subnormal
70	Wongan Hills Research Station	Wongan Hills	Greyish yellow sand, heath country	4·5	. .	. .	Subnormal
88	Smart	Korraling	Yellow sand heath	9·0	.. .	....	High normal
1	Research Station	Avondale	Gritty sandy loam—wandoo and jam	11·8	130	35	High normal
2	Research Station	Avondale	Dark loam near creek—Yorkgum and jam	11·9	61	42	High normal
169	Adams	Northam	Light sand—Christmas tree	3·5	.. .	....	Subnormal

170	Adams	Northam	Brown loamy sand	4·4	149	12	Subnormal
171	Adams	Northam	Brown and loamy sand	3·8	29	15	Subnormal
172	Brown, G. W.	Greenhills	Light soil—wandoo, blackboy, scrub	1·4	..	....	Deficient
17	Reynolds	Meckering	Yellowish grey sand carrying scrub	6·2	166	43	Low normal
4	Plant	Noman's Lake	Sandy loam—jam and wandoo	5·0	74	25	Low normal
218	Plant	Noman's Lake	Sandy loam—jam and wandoo	4·1	....	....	Subnormal
216	Milne	Borden		3·4	..	....	Subnormal
217	Metzke	Yornaning		6·6	..	..	Low normal
168		Boyerine	Sandy soil—wandoo, jam, pin grass	9·7	..	..	High normal

CORRIGIN AND MERREDIN REGIONS

18	Research Station	Merredin	Brown clayey loam—salmon gum, gimlet	6·9	66	37	Low normal
3	Larke	Corrigin	Yellow-brown loamy sand—scrub	9·0	118	27	High normal

EYRE REGION.

219	Light	Gibson's Soak	Grey sand—chittick, Christmas tree, scrub	2·9	58	25	Deficient
220	Pine Plantation	Esperance	Grey sand, gravelly clay subsoil—chittick, Christmas tree, scrub	2·9	....	....	Deficient

* Land treated with copper-containing fertilisers. † Farms on which copper deficiency has been demonstrated by experiments.

APPENDIX B.

COPPER, MANGANESE, AND ZINC CONTENTS OF YOUNG OATS, WHEAT (W), AND BARLEY (B), REPRESENTING SOIL CONDITIONS IN THE WHEAT AND CONTIGUOUS DISTRICTS OF WESTERN AUSTRALIA. PLANTING RANGED FROM MARCH TO LATE JUNE AND SAMPLING BETWEEN 19TH JUNE AND 11TH AUGUST (CHIEFLY IN MONTH OF JULY). SAMPLING RANGED FROM SIX TO NINE WEEKS AFTER SEEDING IN MOST CASES.

(*Note.—Samples not designated* (W) *or* (B) *are Oats.*)

Sample No.	Farmer.	District.	Soil and Vegetation.	p.p.m. dry basis.		
				Cu.	Mn.	Zn.
62	A. Robb	Northampton	Jam—red brown sandy loam	12·8	104	23
94	Drage Bros.	Northampton	Scrub plain	7·9	....	22
1W	Teakle	Isseka	Heath—sand	7·4	113	18
95	M. Royce	Greenough	....	3·9	....	18
60	Burges	Irwin	Yorkgum—red brown sandy loam	6·8	183	24
8W	Pope Bros.*	Caron	Heath—sand and gravel (a)	2·5	96	24
9W	Pope Bros.*	Caron	Heath—sand and gravel (b)	3·0	....	..
82	Pope Bros.	Carnamah	Heath—sand and gravel	3·6	97	16
35	G. McAlpine	Latham	Mallee	10·1	73	33
36	W. McAlpine	Latham	Heath	3·2	119	19
33	I. Roberts	Coorow	Scrub	5·9	94	37
37	J. P. Meehan	Coomberdale	Salmon and gimlet	11·9	57	16

APPENDIX B—continued.

Sample No.	Farmer.	District.	Soil and Vegetation.	p.p.m. Dry Basis. Cu.	Mn.	Zn.
38	J. P. Meehan	Coomberdale	Jam, Yorkgum	3·7		
39	J. P. Meehan	Coomberdale	Jam, Yorkgum	3·3		
4B	Herley Bros.	Gunyidi	Heath—sand on quartzite (a)	9·4	25	14
5B	Herley Bros.	Gunyidi	Heath—sand on quartzite (b)	5·1		
34		Miling	Yorkgum	10·8	91	17
65	Yaodabbie*	Dandaragan	Marri—red sand (a)	1·4	94	16
68	Yaodabbie*	Dandaragan	Marri—red sand (b)	1·5	149	20
16	J. A. V. Brown* (Experiment A)	Dandaragan	Bluegum—brown diatomaceous loam (a)	1·5	234	45
19	J. A. V. Brown* (Experiment A)	Dandaragan	Bluegum—brown diatomaceous loam (b)	1·2		
20	J. A. V. Brown* (Experiment A)	Dandaragan	Bluegum—brown diatomaceous loam (c)	0·9		
23	J. A. V. Brown* (Experiment C)	Dandaragan	Bluegum—brown diatomaceous loam (d)	1·9	98	18
12	Mungedar*	Dandaragan	Marri—brown sand (a)	4·1	33	16
14	Mungedar*	Dandaragan	Marri—brown sand (b)	3·0		
63	C. H. Smith	Koorda	Wodjil—sand and gravel	3·5		
24W	S. Williams*	Hindmarsh (*via* Dowerin)	Heath—sand and gravel	4·2	151	26
26	S. Williams*	Hindmarsh (*via* Dowerin)	Heath—sand and gravel	4·3		
27		Kellerberrin	Sheoak, scrub	2·5	68	15
29		Kellerberrin	Sheoak, scrub	10·4		
48W	Research Station	Merredin	Wodjil—sand and gravel	5·5	237	19
51W	Research Station	Merredin	Wodjil—sand and gravel	12·8		
40W	A. P. Carmody*	Jilakin	Wodjil—gravelly sand (a)	3·9	235	18
42W	A. P. Carmody*	Jilakin	Wodjil—gravelly sand (b)	2·8		
44W	Bebbington Bros.*	Bullaring	Wandoo and scrub—sand on gravelly subsoil (a)	6·3	97	53
46W	Bebbington Bros.*	Bullaring	Wandoo and scrub—sand on gravelly subsoil (b)	5·6		
83	J. C. Trott	Corrigin	Scrub—sand and gravel	12·0	56	43
84	L. Cousins	Bulyee	Wattle and tamar—sand (a)	8·1		
85	L. Cousins	Bulyee	Sheoak, jam, Yorkgum—loamy sand (b)	5·3	120	24
86	C. G. Russell	East Wickepin	Wandoo, etc.—sandy (a)	8·1	81	18
87	C. G. Russell	East Wickepin	Scrub—gravelly sand (b)	10·3		
93B	W. W. Howard	East Wickepin	Sheoak, jam, wandoo—gravelly sand	3·6	22	17
88	M. Green	Toolibin	Wandoo, mallee—sand	5·4	70	25
89	A. Murray	Tinkurrin	Mallee—gravelly sand	7·0	75	39
76	W. H. Bucholz	Katanning	Wandoo—gravelly	6·3	142	30
77	M. W. Ball	Katanning	Marri, jam—gravelly sand	3·5		
75	W. Lloyd Wood	Pallinup	Yorkgum—sandy loam	13·1	50	50
74	R. M. Watterson	Gnowangerup	Mallee—sandy	3·5		
90	A. G. Kingston	South Borden	Wandoo, jam—quartzy sand (a)	6·8	73	31
91	A. G. Kingston	South Borden	Wandoo, jam—quartzy sand (b)	20·0	143	27
92	A. G. Kingston	South Borden	Wandoo, jam—quartzy sand (c)	8·7		
78	H. Brockman	Muradup	Marri—loamy sand (a)	12·7	325	53
79	H. Brockman	Muradup	Marri—poor sand (b)	9·0		
80	Benn Bros.	Boscabel	Wandoo, jam—sandy	4·6		
82	E. Fairweather	Tambellup	Mallee, wandoo—gravelly sand	5·1		
81	F. E. Hitchins	Cranbrook	Yate—sandy	5·4	248	32

* Farms on which copper deficiency has been demonstrated by experiments.

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Vegetable Seed Production.

THE SIGNIFICANCE OF CROSS-POLLINATION.

G. R. W. MEADLY.

The increased interest in vegetable seed production has directed attention to those plants which are likely to hybridise when grown in proximity. A pedigreed crop, due to accidental crosses, may give rise to seed which will produce plants of undesirable types. Thus the results of many years breeding may be nullified in one season.

The risk of such a happening varies considerably with different plants and is influenced by their mode of pollination. It is difficult to group plants under this heading as different varieties or even strains of the same variety may differ considerably in the extent to which self or cross-pollination occurs. External factors such as seasonal conditions may influence the results. For convenience, however, the following general grouping may be made:—

1. Naturally self-pollinated.
2. Naturally cross-pollinated.
3. Flowers of one sex only on individual plants.

These groups are by no means well defined as cross-pollination often occurs with plants which are naturally self-pollinated while the converse is true for the second group. Again plants which are normally dioecious, i.e., bear flowers of one sex only on individual plants, at times have both sexes represented on the same plant.

Obviously cross-pollination is the normal function of many plants, but the difficulty in connection with seed production arises when crosses occur between plants of different types and result in the introduction of undesirable features. The risk of cross-pollination of this nature is greatest when related types of naturally cross-pollinated plants are growing together, although the possibility cannot be dissociated entirely from plants that are naturally self-pollinated. Varieties of cabbage, a "group 2" plant, cross readily but even with peas, which are naturally self-pollinated, artificial hybridisation between varieties can be effected easily and there is a risk, although small, of accidental crossing.

Besides being affected by the mode of pollination, the chances of cross-pollination between plants of different types are influenced to a great extent by the botanical relationships of the plants concerned. To generalise, strains and varieties cross readily, e.g., (*Brassica oleracea var. capitata*) cabbage and kohl-rabi (*B. oleracea var. caulo-rapa*); species less frequently, e.g., turnip (*B. campestris var. rapa.*) and Chinese cabbage (*B. chinensis*); while crosses between different genera are rare, e.g., cabbage (*Brassica oleracea var. capitata*) and radish (*Raphanus sativus*).

For the guidance of vegetable growers a table has been prepared showing:—

1. The "mode of pollination" group.
2. Plants likely to cross-pollinate naturally.
3. Plants which may cross-pollinate naturally but with which crossing is unlikely to be frequent.
4. Plants which are very unlikely to cross-pollinate naturally.

In many cases where there is no information available concerning the possibility of natural cross-pollination, the plants have been grouped according to the behaviour of their affinities. The following notes supplement the information contained in the table:—

1. Many attempts have been made to secure interspecific hybrids within *Phaseolus*, mostly without success except for that involving the French bean (*P. vulgaris*) and the runner bean (*P. multiflorus*). Being self-pollinated however, the risk of appreciable natural cross-pollination is not great.

2. The beet flower is largely wind pollinated and cross fertilization can be effected in areas twelve or more miles apart.

3. *Brassica oleracea* contains the cabbage, cauliflower, borecole, broccoli, brussels sprouts, kale and kohl-rabi, and there is evidence to show that many members of this cabbage group freely intercross when in close proximity at flowering time.

4. The carrot is an example of a protandrous plant, that is, one in which the anthers shed their pollen before the stigma is receptive to pollen. Consequently self-pollination is possible only when the stigmas of the older flowers can be served by the pollen from the younger ones. Failure of isolated umbels to set seed has been due to this protandry.

5. There is a general impression that the cucumber (*Cucumis sativus*) will cross with *C. melo* which includes the musk melons and rock melons or cantaloupes, but experiments do not support this impression.

6. The onion, *Allium cepa* has been crossed with *A. fistulosum* in order to incorporate some of the disease and insect resistant characters of that species. The possibility of crosses between the onion, leek (*A. porrum*) and other onion like plants such as garlic (*A. sativum*) must not be overlooked, although local experience indicates that brown and white onions do not cross readily.

7. The differentiation of pumpkins, squashes and marrows is very uncertain because, as popularly classified, they are included in three species, *Cucurbita pepo, C. moschata* and *C. maxima*. Contrary to popular belief those belonging to different species practically never cross naturally, but varieties of the same species cross very readily. As all three vernacular names are at times, applied to varieties of the same species, as a general rule, when intended for seed purposes, pumpkins, squashes and marrows should not be grown in close proximity. There is no evidence to support the popular belief that pumpkins and water melons should not be grown together because of the immediate effect of cross-pollination.

8. Although peas are naturally self-pollinated, artificial hybridisation between the field and garden pea types can be effected easily and the possibility of a small proportion of accidental crosses must be considered.

9. Although the risk of radish crossing with cabbage or other varieties of *Brassica oleracea* is not very great, an actual radish-cabbage cross is on record, and consequently precautions should be taken.

10. Successful crosses have not been effected between turnip and radish or cabbage, but the turnip has been crossed with the Chinese cabbage (*Brassica chinensis*) and the swede.

11. Certain weeds are known to cross with crop plants, and cause a deterioration of type. Crosses are easily made between wild radish (*Raphanus raphanistrum*) and cultivated radish (*R. sativus*) while weed species of *Brassica* such as field brassica (*B. campestris*) and charlock (*B. sinapistrum*) are likely to cross with some of the cabbage group.

The wild carrot (*Daucus spp.*) must be considered when growing carrots for seed.

In preparing the table and supplementary information, frequent references have been made to:—

Botany of Crop Plants: W. W. Robins, 1924.

Breeding Crop Plants: H. K. Hayes and R. J. Garber, 1927.

Year Book of Agriculture: United States Department of Agriculture, 1937.

SUMMARY.

When growing vegetables for seed purposes, strains and varieties of the same plant, especially if they are naturally cross-pollinated, should not be grown together.

The plants linked by symbols in the table should not be grown in proximity and particular care should be taken with those linked by a cross.

Plants likely to cross-pollinate naturally should be grown at least one half mile apart. With wind pollinated plants such as beets, a considerably greater distance is advisable. Care should be taken to destroy all weeds likely to cross with the crops being grown.

	Method of Pollination	Bean—Broad	Bean—French	Bean—Runner	Beet—Red	Beet—Silver	Borecole	Broccoli	Brussel Sprouts	Cabbage	Cauliflower	Carrot	Celery	Cress—Garden	Cress—Water	Cucumber	Kale	Kohl-rabi	Leek	Lettuce	Marrow	Melon—Citron	Melon—Rock	Melon—Water	Onion	Parsley	Parsnip	Pea—Blue Boiler	Pea—Field	Pea—Garden	Pumpkin	Radish	Rhubarb	Spinach	Squash	Swede Turnip	Tomato	Turnip
Bean—Broad	1																																					
Bean—French	1			⊙																																		
Bean—Runner	1		⊙																																			
Beet—Red	2					×																																
Beet—Silver	2				×																																	
Borecole ...	2							×	×	×	×						×	×														⊙				⊙		⊙
Broccoli ...	2						×		×	×	×						×	×														⊙				⊙		⊙
Brussel Sprouts	2						×	×		×	×						×	×														⊙				⊙		⊙
Cabbage ...	2						×	×	×		×						×	×														⊙				⊙		⊙
Cauliflower	2						×	×	×	×							×	×														⊙				⊙		⊙
Carrot ...	2																																					
Celery ...	2																																					
Cress—Garden	2																																					
Cress—Water	2																																					
Cucumber ...	2																																					
Kale ...	2						×	×	×	×	×							×														⊙				⊙		⊙
Kohl-rabi ...	2						×	×	×	×	×						×															⊙				⊙		⊙
Leek ...	2																								⊙													

Lettuce ...	1																																					
Marrow ...	2																													×				×			
Melon—Citron	2																						×															
Melon—Rock	2																																					
Melon—Water	2																					×																
Onion ...	2																		⊙																			
Parsley ...	2																																					
Parsnip ...	2																																					
Pea—Blue Boiler	1																												⊙	⊙					×			
Pea—Field	1																											⊙		⊙								
Pea—Garden	1																											⊙	⊙									
Pumpkin ...	2																				×														×			
Radish ...	2						⊙	⊙	⊙	⊙	⊙						⊙	⊙																				
Rhubarb ...	2																																					
Spinach ...	3																																					
Squash ...	2																				×										×							
Swede Turnip	2						⊙	⊙	⊙	⊙	⊙						⊙	⊙																				⊙
Tomato ...	1																																					
Turnip ...	2						⊙	⊙	⊙	⊙	⊙						⊙	⊙																		⊙		

POLLINATION TABLE.

1. Naturally self-pollinated.
2. Naturally cross-pollinated.
3. Flowers of one sex only on individual plants.

× Plants likely to cross-pollinate naturally.
⊙ Plants which may cross-pollinate naturally but with which crossing is unlikely to be frequent.

Ants Causing Death in Poultry.

C. F. H. JENKINS, Government Entomologist.

Although at times ants may worry sitting hens or tiny chickens, they are usually considered to be of little importance to poultry keepers. In the last few years, however, several instances of fowl mortality due to the eating of ants have been reported. The most recent occurrence was reported from Dumbleyung in May when many farmers lost fowls under what appeared to them most mysterious circumstances. There was no preliminary sickness and as one correspondent described it, "the birds just dropped dead as you would blow out a candle."

An examination of the fowls' crops showed that they contained a number of reddish-brown winged ants measuring about three-eights of an inch in length and also a number of smaller ants. The ants in question are known as *Monomorium bicorne,* and unfortunately have no popular name. Although poultry mortality from eating ants is not common several species of ants have been known to cause this trouble in different parts of Australia.

The first record of mortality in Western Australia was in about 1923 when J. Clark and G. Allman investigated this matter. In all cases death appears to be caused by the large female ants. The males and workers are so small that they contain only a slight amount of poison (formic acid) and also attract but little attention. As far as I am aware the only places in the State from which trouble has been recorded are Mount Barker, Katanning, and Dumbleyung, but as the ant has a much wider distribution than this it is likely that there have been many unreported cases in other districts.

Fortunately, of course, the danger period is short, for it is only when the female ants are leaving their nests, frequently in the early winter, that they can fall a prey to fowls and other poultry.

Ants removed from crop of dead fowl.

ACKNOWLEDGMENT.

My thanks are due to Mr. J. Clark, Entomologist, National Museum, Melbourne, for the identification of the ants and for notes on its distribution, etc.

REFERENCES.

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Does Early Harvesting of Peas check the Pea Weevil?

A. W. GULL and A. B. ADAMS.

The subject of this note, viz. the possibility that the harvesting of peas when fully grown, but still green, may check the development of the larvae of the Pea Weevil (*Bruchus pisorum*), is queried because one experience does not prove more than the one case.

At Muresk College in the early summer of 1939 one of us (A. W. Gull) gathered the surplus Greenfeast Peas while the pods were still green, with the peas fully developed. These were dried in the pods. The peas were grown in the college garden, and a small quantity of Brunswick White Peas were grown in the grass garden adjoining.

The Brunswick White Peas were allowed to ripen on the plant and on harvest were found to be badly affected with weevil. Practically every pea had one weevil, some had two.

On examining the Greenfeasts when dry they showed no sign of weevil at the time, nor did any weevil develop subsequently.

This experience suggests that it would be well worth while for growers to mow a portion of the pea crop when the pods are full but still green, allow them to dry off on the ground and then collect and thrash in whatever way is customary.

Those harvested in this way can then be compared with those that are allowed to mature in the normal way. Should it prove that the weevil may be controlled by this procedure, it may prove a simpler and more convenient method than that now in use, viz. fumigation with carbon bisulphide.

It will be appreciated if any growers who experiment with this way of harvesting will advise the Agricultural Department of its effectiveness in weevil control.

It is possible that this early harvesting may reduce the vigour and percentage of germination. On the other hand, if they are Blue Boilers, it should benefit their cooking quality.

Agricultural Broadcasts.

The following programme of Agricultural Talks has been arranged for the October-December quarter and will be broadcast from Stations 6WN and Regionals at 9.15 p.m. each Thursday.

Date.	Talk Prepared by:	Title.	Summary.
	I.—FARMERS IN A CHANGING WORLD.		
Oct. 21	H. G. Elliott, Agrostologist, Department of Agriculture	Plant Fibres ...	A classification is given of vegetable fibres together with an account of where they are mainly grown and the uses to which they are put, with special reference to flax.
Nov. 18	Dr. E. J. Underwood, Animal Nutrition Officer, Department of Agriculture	Fertility in Farm Animals	The factors which determine fertility of different kinds of farm stock and the practical means of improving fertility will be discussed.
Dec. 16	C. A. Gardner, Government Botanist, Department of Agriculture	Some Drug Plants of Australia	A talk on the materials at present in use and the potential field for investigations.

AGRICULTURAL BROADCASTS—*continued.*

Date.	Talk Prepared by:	Title.	Summary.
	II.—TOPICAL ITEMS.		
Oct. 28 Nov. 25 Dec. 23	G. K. Baron Hay, Under Secretary for Agriculture will discuss current events in agriculture		
	III.—FARMERS' FORUM.		
Oct. 7 Nov. 4 Dec. 2 Dec. 30	Discussion on topics submitted by farmers—Arranged by Dr. G. A. Currie, Professor of Agriculture, University of Western Australia		
	IV.—TECHNICAL TALKS.		
Oct. 14	C. F. H. Jenkins, Government Entomologist, Department of Agriculture	An Insect Saboteur	A brief outline will be given showing the importance of the Fruit Fly in connection with the necessity for increased food production throughout Australia. The life history and habits of the fly will be briefly touched upon, and control measures will be enumerated.
Nov. 11	I. Thomas, Superintendent of Wheat Farming, Department of Agriculture	Malting Barley ...	The importance of careful harvesting; marketing the crop.
Dec. 9	J. O'Donnell, Fire Control Officer, Forestry Department	The Annual Bushfire Menace	The advent of summer focusses attention on the danger of damage and loss from uncontrolled fires. Diminished manpower in rural districts necessitates early and thorough organisation of prevention and control measures. It is a matter of national importance to reap the maximum returns in farm produce resulting from a good season in the agricultural areas and to minimise capital loss from fires.

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Preparation of the Wool Clip for Appraisement.

W. L. McGarry, Sheep and Wool Adviser.

To obtain full benefits under the Imperial Purchase Scheme a very careful "get up" is essential and many clips are not entering higher types during appraisement owing to inadequate preparation.

While the same basic principles still apply it has been found that under the Appraisement Scheme a greater reduction is made for fault in both wool and classing than was the case under the auction system of selling.

It has been found that in many instances the classing does not conform to the requirements of the various types as laid down in the Appraisers' Table of Limits. Only by carefully following the details laid down can the maximum results be obtained.

In order to secure maximum benefit from the Table of Limits under the existing scheme, it is absolutely essential:—

1. To exclude the odd tender fleeces from an otherwise sound line of wool.
2. To maintain even and regular length in each individual class.
3. To strive for uniformity of quality.
4. To keep separate the odd fleeces carrying excessive condition.

Length is Most Important.

Whilst some provision is made for mixed qualities (60/64's, 64/60's, etc.) there is no elasticity in regard to mixed lengths under the Table of Limits. Wools of mixed length go down in type (and limit) and *full value* for the longer wools in the bale is not obtained.

Under the Table of Limits there is a difference in the prices for average wools of 2d. per lb. (clean) between good length (warp) and medium length (half warp) which on a 50-60% yield is equivalent to 1d.-1½d. per lb.

This serves to illustrate the loss incurred by growers when the all important matter of evenness of length is neglected during the "get up" of the clip.

The minimum length of the staple required to qualify a wool for a "warp" type and so come under the maximum clean scoured basis in its respective group is set out hereunder:—

Minimum length	$2\frac{3}{4}$	inches	for	80's quality and finer.
	3	"	"	70's do.
	$3\frac{1}{2}$	"	"	64's do and broader.

According to the Appraisement Table of Limits a "warp" wool must be absolutely sound and regular. The term "half warp" is applied to wool having all the characteristics of a warp wool without its length.

Tender Fleeces.

In the Table of Limits there is a difference of $1\frac{1}{2}$d. per lb. between a stylish spinners' wool and a good topmaking, but when the latter is tender it results in another 2d. per lb. deduction. In addition, when tender wool is in with sound, the whole lot is relegated to the lower type and the *full value* of the sound wool in the line is not realised. It is essential to keep tender wools separate from sound fleeces.

Quality.

Degrees of merino quality are: Fine, 70's; medium, 64's; strong, 60's.

Growers are advised when preparing their clips to class more in terms of fine, medium and strong rather than spending a lot of time in endeavouring to class out each fleece to strict quality. Exactness in quality is only achieved with years of experience and "border line" qualities are confusing to growers and difficult to determine.

Some of the main factors which reduce good wools to a lower type are mixed quality, mixed lengths, tender and sound together, careless skirting, mixed yielding wools together (i.e., mixing heavy fatty fleeces yielding 40-45 per cent. with good fleeces yielding 55-60 per cent.) and thin, short backs and sticky necks left in good types of sound fleeces.

Best results cannot be obtained for a clip unless the utmost attention is paid to the skirting and, when necessary, the removal of backs and necks from the fleeces. All fault such as seed or burr, stains, rough breech pieces and sweaty edges must be trimmed from the fleece. Almost invariably the back portion of the fleece is shorter, thinner, dustier and less attractive than the side and shoulder wool, and this being the case it must be carefully removed, otherwise the whole line will be relegated to a lower type, with a consequent lower appraised value.

Where weak and wasty backs are left in fleeces it is not possible for the wool so affected to be placed in a warp type.

The necessity for the utmost care and efficiency at the rolling table cannot be too strongly stressed, as it is at this stage that the initial and probably the most serious faults occur. It is impossible to lay down hard and fast rules regarding skirting as this depends largely on the season and the amount of skirting necessary depends, of course, on the conditions under which the sheep are run, and the amount of seed and/or burr, dust or foreign matter in the fleece.

Efficient and adequate skirting of fleeces from year to year must be left to the discretion of the classer and grower. To obtain the *full* benefit of skirting it is essential to *remove only all that is necessary* and leave intact on the fleece *all* that can be left. Heavy skirting, if not warranted, is unprofitable because much good length free wool finds its way to the piece bins with overskirting.

Some growers have the erroneous idea that the mere act of removing a skirting from a fleece is sufficient. Such is not the case. This removal has attended to the fleece, but has quite overlooked that portion of the fleece which has been removed. In this respect it is essential to remember that something is *gained* if the skirting is done correctly, but that something is also definitely *lost* if once having removed the skirtings and broken wools you neglect same by bundling them all in together. The importance of grading the oddments (PCS, BLS, etc.), cannot be over-emphasised because in some clips and in some years the oddments may represent up to 50 per cent. of the total clip. To obtain the maximum return per sheep, it is necessary to give these oddments the attention they warrant by grading them in the same manner as the fleece wool. If labour shortages at shearing time preclude the picking of pieces and grading of oddments, stack same in shed or pack temporarily until shearing is completed. Picking can then be effected and also during wet weather when the shearers are off the board.

A sound practice in classing is never to force a line of wool. This often occurs when "borderline" fleeces are encountered. That is if a fleece is encountered that is say half-way between the AAA (1sts) and AA (2nds) and matching is difficult, always put it down into the lower line. In this manner you are *increasing* the value of the lower line and retaining the evenness and consequently enhancing the value of the top line.

However, this practice should not be overdone because profitable classing calls for as much top line wool as possible. The necessity for forcing the lines will not occur, however, if the standard is set correctly at the commencement of the classing. It is *very necessary* to set the standard of the various lines according to the wool *before* you and not according to some preconceived idea of what AAA or AA (as the case may be) should look like.

After the lines have been "set" or in other words after the classer has decided in his mind's eye after an inspection of the first 30 or 40 fleeces what is to be AAA, AA, BBB and so on, the main considerations to remember are:—(1) Length, (2) Quality, (3) Soundness, (4) Yield.

Classing may be summed up in this phrase:—"Put wool where it fits and matches" and naturally evenness of length, quality and condition will be found together.

The number of lines to be made will be governed by the size of the flock and the condition and quality of each individual clip from year to year.

Discretion must be used as to the number of lines made as it is desirable not to cut a small clip up into too many lines. At the same time, however, the value of EVENNESS OF LENGTH AND QUALITY cannot be over-emphasised.

Tender wools must be kept out of sound lines. This is important.

Any irregular sorts which do not match any of the lines must be kept separate and placed in bags or butts.

Fleeces must be carefully skirted for sweat, stain, seed and burr.

Particular attention must be paid to the removal of geranium seedy jowls and cotts, as the presence of these will reduce good wools to a lower type with consequent loss to the grower.

Back wool where noticeably shorter and inferior in type to the remainder of the fleece should be removed. Brand the neck portion NKS and the remainder BKN.

Black tipped, heavy fatty fleeces must be kept separate from medium conditioned wools.

All rams' wool must be kept separate and branded as such.

The following classes are applicable to Agricultural and Southern merino clips. The number of descriptions used will be governed by the size, condition and quality of the clip being classed.

SUPER—Only to be made from clips which warrant description for style, quality and quantity.

AAA COM—Sound, good length, light conditioned, fine/medium quality.

AA COM—Sound, shorter, heavier, fine/medium quality.

A COM—Short and very heavy, also black tipped fleeces.

AAA FLC—Tender, good length, light/medium condition.

AA FLC—Tender, shorter, heavier condition.

(Any strong quality tender fleeces which do not match the last two descriptions should be placed in bags. If sufficient strong tender wool is encountered make a BBB FLC line.)

BBB COM—Sound, good length, light/medium condition, strong quality.

BB COM—Shorter, heavier, strong quality.

(Anything very rough, or doggy fleeces should be placed in bags or fadges. If sufficient for a bale and in strong quality clips a line of 58's can be made.)

AAA PCS—Longest, lightest and brightest.

AA PCS—Shorter and heavier.

(Breech pieces, very strong quality pieces and starey necks should be kept separate. In strong quality clips a line of BBB PCS can be made.)

(Pieces cotted with geranium seed should be packed entirely separate and not mixed through any of the above lines—Brand SDY PCS.)

It is important that all pieces be shaken thoroughly in order to eliminate second cuts and locks. Piece lines carrying second cuts and locks go down in type and lose 1d. to 2d. per lb. in value owing to the loss in length and the lower yield. It is equally important of course to thoroughly shake the locks in order to remove and secure full value for the pieces that are often mixed through the locks.

Piece picking can be effected with much more efficiency and speed if the breech skirtings are thrown in a basket or kept separate when the fleece is being skirted. This procedure saves double handling and automatically separates the stained strong, and inferior seedy breech pieces from the longer, freer, and brighter shoulder and side pieces.

BKN—The backs.

NKS—The longer, brighter and higher yielding neck portion.

AAA BLS—One line, skirted free of heavy sweat and stain. (Two lines may be made if the size of the clip warrants it. The second line, AA BLS will be the shorter, heavy conditioned BLS free of stain.)

STD PCS—One line minus dags, thoroughly dried.

LKS—One line, minus dags.

AAA LBS—Longest, brightest, light to medium condition, minus stain.

AA LBS—Shorter and heavier conditioned, minus stain (any rough, coarse lambs' wool to be placed in bags.)

Comeback and Crossbred Clips.

AAA CBK—Good length, light to medium condition comeback wool.

AA CBK—Shorter and heavier conditioned comeback wool, may include tender fleeces from AAA CBK.

AAA F XB—Good length, light to medium condition, fine quality crossbred wool.

AA F XB—Fair length, light to medium condition, may include tender fleeces from AAA F XB.

AAA XB—Good length, light to medium condition, medium quality—crossbred wool.

AA XB—Fair length, light to medium condition, medium quality—may include tender fleeces from AAA XB.

XB—Good length, light to medium condition, strong quality Crossbreds and long English breeds.

XB COM—A cast line, cotty, discoloured and rough fleeces.

SHROPSHIRE, DORSET, DOWNS AND SIMILAR BREEDS—Brand according to breed and bag if insufficient for a bale.

CBK PCS—Comeback and fine Crossbred PCS, minus sweats.

XB PCS—Medium and strong quality Crossbred PCS, minus sweats.

CBK BLS—Comeback and fine Crossbred BLS, minus sweats and stains.

XB BLS—Medium to strong Crossbred BLS, minus sweats and stains.

XB & CBK, STD PCS—One line, minus dags, thoroughly dried.

XB & CBK LKS—One line, minus dags.

CBK LBS—Fine quality, minus stain (two lines if necessary, according to length).

F XB LBS—Medium quality, minus stain (two lines if necessary, according to length).

XB LBS—Strong quality lambs' wool, minus stain.

Where flocks are mixed (Merino and Crossbred) always draft the sheep before shedding and treat the wool as two clips. This procedure will simplify and reduce the work involved in the wool room. Growers are strongly advised against mixing Merino and Crossbred wool in the same bales. Appraisers will order mixed fleece wools of such dissimilar type to be re-classed at the owner's expense before valuation can be effected. Mixed Crossbred and Merino pieces will relegate the lot to a lower type with a consequent loss to the grower.

Pressing and Branding.

Neat, well pressed bales facilitate handling, save packs and are a general all round advantage. When pressing it is advisable not to make the bales containing top line wool too heavy. It is an advantage also if the weights of such bales are kept fairly even and without a great variation in poundage. A reasonably high over all bale average is necessary to conserve wool packs, and this can be effected by increasing the weights in the lower lines of oddments.

The bales in the clip must be numbered consecutively from No. 1 on to the end of the clip, with oddments following on in sequence. Do not duplicate numbers in any one season.

A plain brand which is distinctive and bold should be used. The owner's initials over the name of the property are recommended. The initials serve as

a distinguishing mark, as many farm names are duplicated. The use of stencil plates is strongly recommended and small letters should not be used.

The brand, description and bale number must be clearly marked on the front *and top* of each bale. Do not brand on bottom of bale. Front of bale should be a side with a seam all round. Where no mechanical press is available, and fixed top packs are used, the same method applies, but *front* of bale should be opposite to side to which cap is attached.

The minimum weight of a "full weight" bale of greasy wool is 200 lbs.

It is essential that the classer or grower renders to the wool broker a report on the clip, giving the bale numbers of any "splits" in the flock, and stating whether a change has occurred in the wool. This could occur through a change in the type of country, a different paddock, or a change of flock during shearing.

Thrips, and their Relation to Spotted Wilt and Other Plant Injury.

C. F. H. JENKINS, Government Entomologist.

There are a large variety of thrips found in Western Australia, some are native species, but many are world-wide types which have been introduced, and of these several are of considerable economic importance. Although thrips are by no means specific as regards the plants attacked, different species show preferences for certain hosts, and so we have such popular names as apple thrips (*Thrips imaginis*), onion thrips (*T. tabaci*), carnation thrips (*Frankliniella insularis*), and gladiolus thrips (*Taeniothrips simplex*), for the species which habitually attack these plants.

As a matter of fact, the apple thrips and the onion thrips both attack roses and the onion thrips and the carnation thrips both may be found upon tomatoes and various other plants, so that the host plant is by no means a sure guide to the species of the insect.

GENERAL DESCRIPTION.

Thrips are minute elongate insects somewhere about 1/16th of an inch in length, yellow, yellowish brown, brown or black in colour, according to the species. The adults possess two pairs of narrow wings fringed with long delicate hairs.

The wings are usually folded closely over the back and so are not easily seen. The immature thrips or nymphs are found feeding in the same situation as the adults, but are usually lighter in colour and devoid of wings.

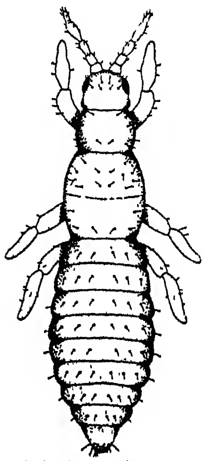
LIFE HISTORY.

The life history of the thrips will of course vary according to the species, but the general sequence of events is as follows:—

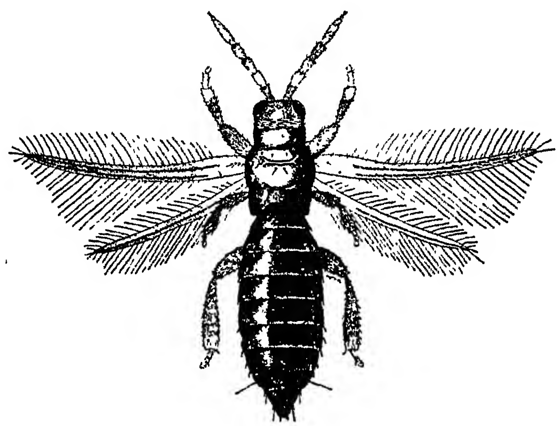
The female has a tiny saw-like organ called an ovipositor near the posterior end of the abdomen, and by means of this she makes slits in the leaf, stem or flower parts of the host and inserts minute white eggs in the tissues. The eggs

hatch in a few days and the immature thrips soon commence to feed. After feeding for several days the nymphs enter two resting stages known as the pre-pupal and pupal stages, both of which are passed in the soil. At the conclusion of these stages, the adult winged thrips emerge from the ground and soon set about the business of egg laying.

Under favourable spring and summer conditions the time required for the insect to develop from the egg to maturity is about three weeks, although under winter conditions the various stages of the life cycle may be greatly lengthened.



(Cal. Dept. Agric.)
Larval stage of gladiolus thrips
(highly magnified).



(Cal. Dept. Agric.)
The adult gladiolus thrips
(highly magnified).

TYPE OF INJURY.

Thrips injury may be manifested in two ways, due either to the actual feeding marks of the thrips or to the transmission of agents known as viruses. Feeding injury may be roughly classified into three types according to the parts of the plant attacked, namely, leaf injury, blossom injury, or corm injury. In feeding the insect rasps the outer surface of the tissues with its tiny mouth parts and sucks up the liberated juice. The injured parts become silvery or whitish, and this discolouration of both foliage and flowers is well known to gladiolus growers. As every apple and rose grower knows, when developing buds are heavily infested they may shrivel and fail to open.

VIRUS TRANSMISSION.

The damage caused by thrips in their role of virus carriers is even more important than the losses caused by feeding injury, and presents a problem which is much more difficult to solve. Just as malaria is transmitted from man to man by mosquitos, so may certain virus diseases be spread by thrips. *Spotted Wilt of Tomatoes* is the most important thrips borne virus in this State. It is carried by the yellowish onion thrips and the darker and less common black carnation thrips.

The control of spotted wilt is closely bound up with the control of thrips, for it is only by eradicating or keeping in check the carriers of the virus and by destroying diseased plants that the menace can be overcome.

CONTROL.

The control methods which can be used against thrips will vary according to the nature of the attack.

The apple thrip, which periodically causes poor setting of the fruit crop, is still an unsolved problem, for the plagues arise so rapidly and the areas covered are so large that although effective sprays and dusts are available the expense and difficulty of application is enormous.

In the case of crops such as gladiolus, celery, onions, and tomatoes, control measures can be more effectively applied. The treatments may be divided into two types, those involving contact dusts and sprays, and those consisting of poisoned sugar solutions. In carrying out any control measures it is necessary in most cases to commence the treatment as soon as the plants appear above the ground and before a heavy infestation has arisen. Especially is this so where it is desired to control virus disease, for a few infected insects may cause a great deal of damage.

In the case of tomatoes, seed beds should be regularly treated at least once a week and preferably twice, so that no serious infestation can become established before the plants are set out in the field.

BAITS.

The following sprays should be applied about once a week or even more often where it is necessary to reduce the thrip population to an absolute minimum:—

1. Tartar emetic, 1 to 2 oz.
   Brown sugar, 4 oz.
   Water, 4 gallons.

This spray has been used locally with very excellent results in controlling gladiolus thrips, and is reported to be of great assistance in reducing spotted wilt.

Tartar emetic is unfortunately sometimes difficult to procure, however, and the following alternative formulae are included:—

2. Paris Green, 2 oz.
   Brown sugar, 4 lb.
   Water, 5 gallons.

3. Manganese arsenate, 4 oz.
   Brown sugar, 4 lb.
   Water, 5 gallons.

Slight foliage injury may result from the use of the last two formulae, especially under humid conditions.

The following formulae have recently been found very effective substitutes for tartar emetic sprays in America, and although they have not yet been fully tested out locally they are included for the benefit of growers who may feel disposed to try them:—

1. Nicotine sulphate, 1 quart.
   Honey, cane syrup, or corn syrup, 3 gallons.
   Water, 83 gallons.

2. Paris Green, 7 ozs.
   Molasses, 2 quarts.
   Water, 83 gallons.

In addition to the above, another substitute worthy of trial on some plants is the formula, commonly used for fruit fly baiting:—

Sodium fluosilicate, 1 oz.
White sugar, 2½ lbs.
Water, 4 gallons.

This spray will severely burn gladiolus foliage and certain other plants, but preliminary experiments have shown it not to affect tomatoes, and in the absence of other insecticides growers may feel disposed to test this material.

Dusts.

1. Tobacco dust, 1 part; slaked lime, 2 parts; flowers of sulphur, 1 part.
2. Kaolin or talc, 70 parts; Derris powder, 20 parts, pyrethrum, 10 parts.
3. Pyrethrum, 1 part, flowers of sulphur, 9 parts.
4. Flaked naphthalene.

Contact Sprays.

1. Nicotine sulphate or black leaf 40, 1½ teaspoonsful; soap, 1 oz.; water, 1 gallon.
2. Nicotine sulphate, 1½ teaspoonsful; prepared white spraying oil, ⅕ pint: water, 1 gallon.

Treatment of Gladiolus Corms.

1. Immerse in warm water 120 deg. F. for 10 minutes, or 112 deg. F. for 30 minutes. Care should be taken to see that the temperatures are not exceeded.

2. Place corms in a paper bag or box with flaked naphthalene at the rate of 1 oz. to every 100 corms. Leave containers closed for about three weeks or a month then remove naphthalene.

3. Dip just before planting in solution of corrosive sublimate 1 oz. to 6 gallons.

Cultural Methods.

As in the control of most other pests, garden hygiene will play an important part in checking thrips injury and thrips borne diseases. Neglected plants and weeds are a harborage for the pest and in many cases may also be infested with spotted wilt, with the result that they are a potential menace to any susceptible crop cultivated in the vicinity. Crops very liable to thrips damage are best grown in as isolated a position as practical, for thrips have been known to fly 200 feet under calm conditions, and with the aid of the wind this distance could be increased greatly.

Self Feeders—A Method of Reducing Labour in Pig Raising.*

M. CULLITY, Superintendent of Dairying.

The rapid expansion of pig raising is one of the greatest needs at present facing Australia and this State is being called on to produce a very big part of the pig-meats to be supplied to Great Britain under contract.

* Incorporating information supplied by R. R. Rutherford, M.D.A., Farm Manager, Muresk Agricultural College; C. R. Dixon, M.D.A., Piggery Instructor, Muresk Agricultural College.

Fortunately this State has a large potential for pig production both in the wheat and dairying areas, although it is in the former that the most rapid expansion is possible.

The Commonwealth Government has announced a plan which guarantees prices which are a very substantial advance on those operating before, for a period of at least two years. In normal times such a plan would undoubtedly immediately lead to increased output. At the present time the major difficulty of shortage of labour is a tremendous handicap and unless this is overcome the promise of good prices will not achieve its object.

Fortunately the labour required for feeding and handling pigs can be reduced by thoughtful organisation of the feeding methods and the lay-out of the premises.

There are various types of self feeders available on the market which can be adapted for pig-feeding, but two types which can be made by the farmer himself are described in the following notes:—

1. Self-feeders which have proved successful at the Muresk Agricultural College are made from old 44-gallon oil drums. Both ends of the drum are removed: four L-shaped pieces of iron, which act as legs and keep the drum raised 1½ inches from the base of the feeder, are bolted to the drum: an old implement wheel tyre (such as a binder wheel tyre) filled with 3 in. of reinforced concrete is used as a base (diameter of the base would be 18 inches greater than that of drum). This allows 9 in. all round the drum for feeding.

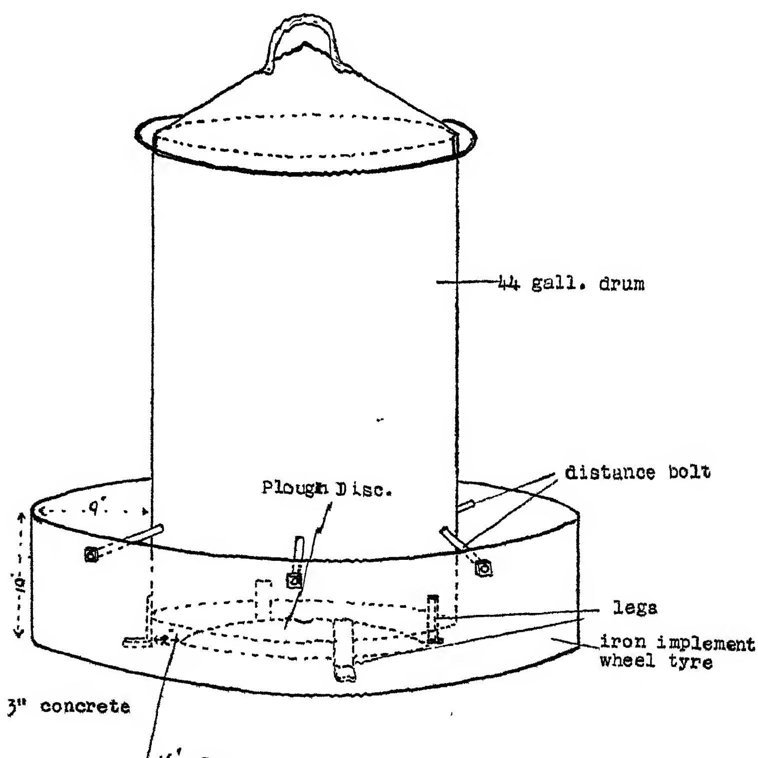


Fig. 1.

To allow the feeder to empty out, an old plough disc or cone should be placed in the centre of the base. This will carry the feed to the tray. The ideal width of the tyre used for the base is 10 in., as narrower types allow feed to be scattered and wasted. The drum is stood in the centre of the base and secured with four distance bolts. The provision of a lid for the drum completes the self-feeder (see figure 1). This size self-feeder has the advantage over larger types in that it can easily be moved to clean ground.

It has been found an advantage to have the feeder on a wooden platform 6 ft. x 6 ft. built in the form of a sledge to facilitate moving when necessary. Another advantage is, during wet weather pigs do not carry slush on their feet into the self-feeder and thus cause it to stop running.

2. Another type has already been described in this Journal (December, 1940).

"The Feed Trough.

The self-feeder rests on two 4 in. x 2 in. skids provided with two strong flat iron draught lugs, which render it portable. Three 4in. x 2in. bearers are then notched over the skids. On top of these bearers the feed trough is formed, the bottom being 10 in. x 1 in. and the sides 5 in. x 2 in. on the edge bolted to bearers with ⅜ in. bolts through the skids and bearers. Two pieces of 8 in. x 1 in. wood placed at 45 degrees form the centre or back of both troughs, and two pieces of 5in. x 1in. wood placed at 45 degrees from the 5in. x 2in. sidepieces to the bottom board complete the feed trough.

The Bin.

The bin, or hopper, is constructed of wood. The frame is made of 3 in. x 2 in. uprights with 3 in. x 1 in. across the top. Rafters of 2 in. x 2 in. and 4 in. x 2 in. ridge. The top is sheathed with 6 in. x ⅞ in. tongue and grooved boards; one side of the top acts as the door, which is composed of 6 in. x ⅞ in. tongue and grooved board with two 6 in. x 1 in. ledges. The door and top are covered with flat iron: hinge door with three strap hinges.

The top should project well over the trough, so that water will not drip into it. The side and end of the bin should be sheathed with 6 in. x ⅞ in. tongue and grooved boards. The bin is supported by 2 in. x ⅜ in. iron straps bolted to trough and to bin.

The slide and hinged flap are regulated with a slot and bolt and screw; the bottom of the slide is hinged with strap hinges. The slide is 8 in. x 1 in. wood, the flat 4 in. x 1 in. wood, with a strip of tin or light iron 3 in. wide to cover the crack. The whole structure measures 6 ft. long x 3 ft. wide, the eaves projecting 6 in. all round."

3. Mr. G. Moullin of Mukinbudin has in use a self-feeder made from a 1,500 gallon tank. He has built a cone approximately two feet high in the centre and has bolted to the base four trays. From the centre of the cone pieces of ⅜ in. iron pass through 1 in. holes. The pieces of iron project into the tray and are turned up so that the pigs agitate the wheat, so causing it to flow.

Number of Pigs per Feeder.

As a general rule four pigs can be fed for each linear foot of feeding trough; for example—in a feeder with trough 5 ft. long on each side, it would be possible to feed 40 growing pigs.

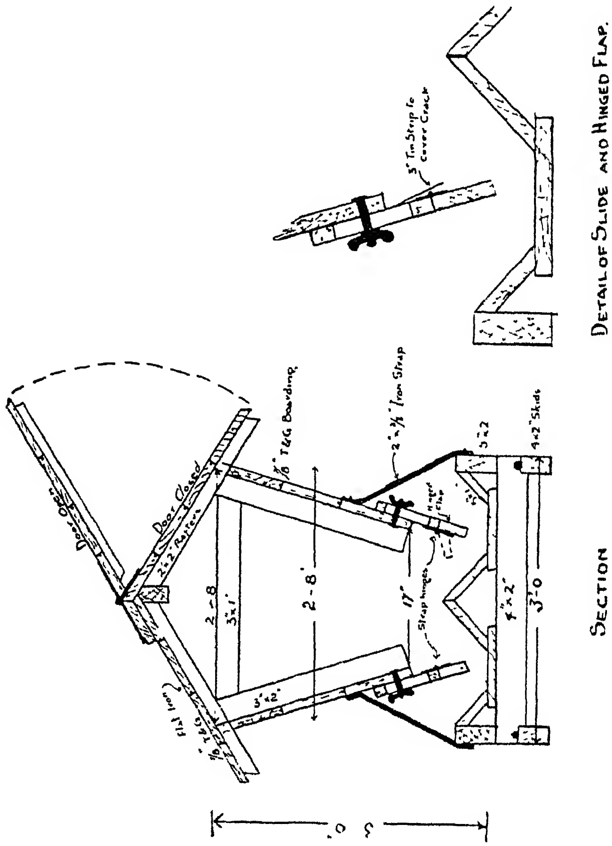

Door Open
Door Closed
2x2 Rafters
7/8 T&G Boarding
Flat Iron
2 x 3/8 Iron Strap
Hinged Flap
Strap hinges
4x2 Skids
2-8
3x1
2-8
3x2
3-0
5' 0"
Section
Detail of Slide and Hinged Flap.

Fig. 3.

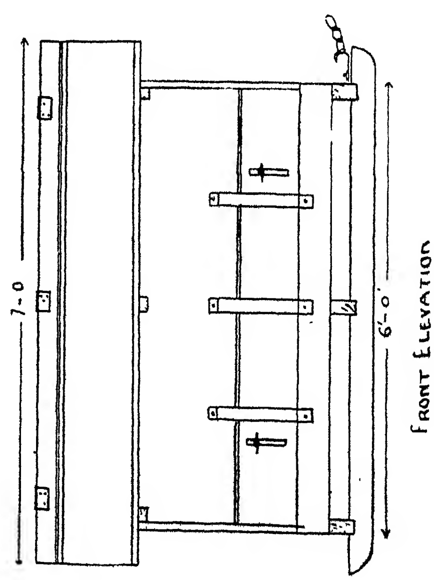

7-0
6'-0"
Front Elevation

Fig. 2.

In the feeder referred to as type 2 above, the hopper would have capacity to hold sufficient grain for 40 pigs nearing baconer weight for four to five days.

In the type 1 feeder, as used at Muresk College, it was found possible by filling the hoppers five times per week with a mixture of crushed wheat, barley and ten per cent meatmeal to feed 38 mixed pigs; 25-30 porkers or 20-25 baconers.

It will be appreciated that by increasing the number of feeders and so reducing the number of pigs per feeder, the need for refilling the hoppers will not be so frequent.

Rations to be Used.

Experiments conducted at the College have shown that a protein supplement such as meat-meal should be used with wheat and as a general recommendation when other forms of supplement are not available, it is advised that the wheat and meatmeal should be provided in the proportion of 9 : 1.

However for several months in each year it is possible to allow pigs access to grazing of green pasture or cereal crops. In this way the requirements for protein in the feeder are reduced and a ratio of 20 of wheat to one of meatmeal will be found sufficient. It will be found however, that semi-mature or mature pasture or fodders will not give the same result, due to the lower protein content and the increased amount of fibre. The provision of ample protein in the early months is necessary in order to allow the young pigs to develop a large skeleton with an ample covering of muscle.

Many farmers are following the practice of eliminating meatmeal from the ration in the latter months of the feeding of a bacon pig and while they may be producing pigs of satisfactory weight, the indications are that this method tends to produce a pig with too high proportion of fat to lean meat.

When meatmeal is in short supply, linseed-meal can be used to replace portion and the ratio could then be meatmeal and linseed-meal in the proportions of 27 : 2 : 2 in the absence of grazing, or 27 : 1 : 1, where grazing is available.

Further labour can be eliminated by providing the grain and supplements in separate compartments or in separate feeders. For example—in the type-2 feeder, a partition can be introduced one foot from one end and used for meatmeal while the remainder of the hopper is filled with grain. It will be found that the pigs will take the protein supplement in quantities to allow rapid growth and in a proportion to wheat very little different from that recommended for use when the ration is mixed.

Mineral supplements can be provided by adding 2 per cent. of limestone to all mixed rations or by placing a supply of limestone in a box near the feeder where the pigs will take what they require.

Preparation of grain.

Although pigs will use grain with greater efficiency in producing meat when crushed, the work of gristing requires considerable labour and time. In the present circumstances, therefore, a considerable saving can be effected by using whole grain. It will be found that although some increase in the quantity required will occur, satisfactory pigs will be grown.

Preparation of young pigs for self-feeding.

It is essential in order to provide for maximum development of suckers and to avoid check to growth at weaning that the young piglets be provided with feed

apart from the mother. This may be accomplished by penning off a small trough in the corner of the breeding pen, or yard, by means of a hurdle wide enough between the bottom rails to allow the piglets access to the trough and close enough to keep out the sow. The creep-feeder should be made available to the piglets when two weeks old and its use be continued until weaning, allow approximately ¼ to ½ lb. feed per head per day at two weeks and increasing the rate to 1-1½ lbs. at weaning or 8-9 weeks old. Suckers given access to creep-feeders will thus become accustomed to supplementary dry feed, be brought to maximum weights at weaning time, and suffer less check when weaned. The value of creep-feeding, therefore, cannot be over emphasised.

Water supplies and shelter.

Apart from the economy of allowing the pigs access to green grazing, there are two other points which demand attention by the farmer planning to adopt a system of self-feeding. These are the provision of water and shelter. All animals require water to maintain their bodies and to allow growth. In the summer months their needs are greater. The provision of clean wallows is a further advantage, particularly for sows with pig or litters.

Suitable accommodation to protect the pigs from the sun in the hot weather and to provide warmth in the winter months is also needed. Simple brush shelters as illustrated in Fig. 3 are satisfactory in the summer months. For winter, shelter walls are needed to shield the pigs from cold winds.

Portable feeders may be moved in the summer to shady places and in winter to where windbreaks are available.

Some results at Muresk.

At the College a mixture of crushed grain with 10 per cent. meatmeal and 2 per cent. dicalcic lick is used.

1. Twenty-one weaners comprised of approximately even numbers Tamworth and Berkshires and Tamworth-Berkshire cross, were fattened by the use of a self-feeder and sold on 12/5/43. They had access to green grazing over the last 2½ months. They sold as follows:—6 heavy baconers at 100s. each; 9 heavy baconers at 97s. 6d. each; 5 heavy baconers at 94s. 6d. each, and 1 light baconer at 88s. 6d. Average 97s. 1d. each.

2. Twenty-six weaners were fattened by the use of a self-feeder during the summer and sold 18/3/43 (mixed culled pigs) with no access to green grazing:—21 baconers at 89s. 6d. each; 1 baconer at 93s. 6d.; 2 baconers at 75s.; 1 light baconer at 68s.; 1 baconer at 85s. 6d. Average 87s. 6d.

3. A group of 10 pigs were sold 7/6/43 and averaged 104s.

4. Culls from stud—14 baconers, hand-fed, sold 27/10/43 averaged 82s. 1d.; 4 baconers at 76s.; 1 baconer at 80s.; 9 baconers at 85s.

Results at Mukinbudin.

A recent communication from Mr. G. H. Moullin, "Cookabin," Mukinbudin, showed that without help he was able to handle approximately 140 pigs in addition to 700 sheep.

Mr. Moullin states that he has nine sows which are kept together until they are due to farrow, when they are separated and kept in sties nine feet wide by 25 yards long. He used cyclone pig-netting, strained tightly, and has found this very satisfactory.

The young pigs are weaned at 8-10 weeks, are wormed with "Wurmozol" and put into a 50 acre paddock with self-feeder, trough and ball tap and 25 acres of crop sown for them. They stay there until brought down as baconers.

About 70 to 100 pigs of all ages are run in this paddock and the self-feeder which has a capacity of 38 bags is filled approximately once a month with whole wheat.

Mr. Moullin further states that at first he followed the practice of crushing the wheat and adding four bags of meatmeal. He found this method was definitely better, but now he has not sufficient time to do it.

He has a Horwood-Bagshaw grister, a home-made 9ft. elevator and has put through 80 bags on a summer afternoon. The elevator directs the gristed wheat into a tank. The work of gristing is carried out without assistance. This farmer states that the trays of the self-feeder should be level with the outlet in the container and not lower as so many are: in this way no wheat is soured or wasted. About 500-600 bags of wheat are used in the year.

From the foregoing there can be no doubt that self-feeders can be used in such a way so as to reduce the amount of work required in feeding pigs to the occasional filling of the hoppers and the loading of the pigs for market.

Some Organic Manures used with Vegetables.

L. T. JONES.

In order to obtain maximum efficiency in vegetable production with the supplies of fertiliser available, the Department of Agriculture has recently commenced a programme of experiments in collaboration with commercial growers in the metropolitan area. These experiments have been designed to test the value of various fertilisers applied at different rates and in a number of combinations. The most important organic fertilisers used in these experiments, or in adjacent commercially grown crops, have been analysed to determine their composition so that plant food equivalents of each dressing could be calculated and the responses examined in this light.

THE ORGANIC MANURES ANALYSED.

1. *Scouring Works Waste.*

This material consists of the sediment remaining in the vats when the wool is washed with potash soaps. The sample examined appeared to consist mainly of sheep manure and wool, but different batches are liable to vary in composition.

2. *Barley Combings.*

Barley combings are a by-product of the malting industry and consist of the dried sprouts of the malted barley grain.

3. *Blood and Bone Manure.*

This manure is produced from slaughter-house waste and includes blood, bone, and animal flesh.

METHOD OF REPORTING THE ANALYSES.

The estimations are expressed as percentages of nitrogen (N), phosphoric acid (P_2O_5), and potash (K_2O). These analyses become more intelligible when nitrogen is expressed as sulphate of ammonia, phosphoric acid as superphosphate, and potash as sulphate of potash. For convenience of comparison the estimations have been calculated to show the equivalent of one ton of the organic manure, at the normal moisture content as applied in the field, in terms of the corresponding commercial fertilisers.

ANALYSES OF MANURIAL CONSTITUENTS ON NORMAL MOISTURE CONTENT BASIS.

(Analyses carried out in the Government Chemical Laboratory.)

Fertiliser.	Scouring Works Waste.	Barley Combings.	Blood and Bone Manure.
	%	%	%
Nitrogen (N)	2·22	4·27	5·11
Phosphoric Acid (P_2O_5)	0·53	1·41	15·69
Potash (K_2O)	3·04	2·12	0·25
Moisture	...	14·12	...

EQUIVALENT AMOUNTS OF ARTIFICIAL FERTILISERS IN 1 TON OF THE MATERIAL.

Fertiliser.	Scouring Works Waste.	Barley Combings.	Blood and Bone Manure.
	lbs.	lbs.	lbs.
Sulphate of Ammonia (20% N)	249	478	572
Superphosphate (18% P_2O_5)	66	176	1,953
Sulphate of Potash (48% K_2O)	142	99	12

COMMENTS ON THE MANURIAL VALUE OF THESE ORGANIC MANURES.

Plant Food Concerned.	Scouring Works Waste.	Barley Combings.	Blood and Bone Manure.
Nitrogen	Fair	Fairly good ...	Good
Phosphate	Low—needs supplementing	Supplementing with super. generally an advantage	High—but slow acting.
Potash	Fairly good ...	Fair	Poor

RESPONSES OBSERVED WITH THESE MANURES.

1. *Scouring Works Waste.*

Some cauliflowers grown with this manure were suspected of showing potash deficiency symptoms. Potash manures were applied late in the season but did not remedy the trouble. Analyses of healthy and affected leaves gave similar potash

contents. Later the use of this manure with turnips resulted in too vigorous top growth. The analysis indicates that a better balanced manure would result if superphosphate were applied in addition.

2. *Barley Combings.*

In a recent fertiliser experiment it was observed that cabbages receiving no potash showed severe potash deficiency symptoms, while adjacent commercially grown cabbages receiving about one ton per acre of barley combings showed only slight potash deficiency symptoms. From the analysis of this material it is evident that the cabbages were able to obtain a fair supply of potash from the barley combings.

3. *Blood and Bone Manure.*

Blood and bone manure has always been a favourite with orchardists, vignerons, and vegetable growers and this preference may be explained in part by the following facts.

In a fertiliser experiment with cabbages located on a black peaty soil there were indications that blood and bone manure owed part of its superiority to the fact that it contains, to some extent at least, the necessary minor elements for continued maximum plant growth on this soil type. It was found that under these soil conditions mineral fertilisers, plus minor elements, were practically as effective as blood and bone manure.

The additional elements applied along with the normal mineral fertiliser (consisting of superphosphate, nitrate of soda, and sulphate of potash) were magnesium as Epsom Salts, copper as bluestone, manganese as manganese sulphate, and zinc as zinc sulphate.

For purposes of comparison the blood and bone used in these experiments was analysed for magnesium, copper, manganese, and zinc.

The experimental evidence is not complete enough to be able to point definitely to any one element as being directly responsible for the better growth of cabbages on this black peaty soil. However, the probable importance of magnesium (supplied by Epsom Salts) to sustain maximum crop yields under certain conditions is now being more fully realised. The zinc content is higher than one would normally expect from an organic material but this may be due to contamination.

ADDITIONAL ELEMENTS IN THE BLOOD AND BONE SAMPLE.

Element.	Analysis.
Magnesium (Mg)	0·35%
Copper (Cu)	13 parts per million
Manganese (Mn)	12 parts per million
Zinc (Zn)	160 parts per million

EQUIVALENT AMOUNTS OF THE CORRESPONDING CHEMICAL SALTS IN 1 TON OF THIS BLOOD AND BONE MANURE.

Commercial Chemical Salt.	1 Ton of Blood and Bone Manure Contains :
Epsom Salts (9·9% Mg)	80 lbs.
Bluestone (25·4% Cu)	2 ounces
Manganese sulphate (14% Mn)	3 ounces
Zinc sulphate (26·4% Zn)	22 ounces

THE INTERPRETATION OF THE ESTIMATIONS.

1. *Relative Availability.*

It should be borne in mind that the nitrogen, phosphate, and potash in these manures is in an organic form and would not be as readily and as rapidly available to the plant as in the form of the corresponding artificial fertilisers. Depending on conditions this difference in availability can be an advantage or a disadvantage. Where leaching is severe, nitrates and ammonia would be liable to washing out and nitrogen in the less soluble organic form would, in this case, be an advantage.

2. *Plant Food Delivery.*

The delivery of plant food in an organic manure being brought about by soil micro-organisms is a continuous process, the rate depending on the activity of the micro-organisms. As plant food is being released over the period of decomposition, the plants tend to be fed regularly rather than spasmodically. This aspect of plant nutrition is very important when the supply of nitrogen to the plant is concerned.

When a high grade organic manure is added to a vegetable crop at planting time, there is a tendency under suitable conditions for the peak in plant food production to coincide with the plants maximum needs. It has been stated, that, for potatoes, the period of maximum uptake of plant food is 50 to 80 days after planting. The quicker-acting artificial fertilisers if applied at the wrong time, may be lost to the plant or even be harmful if in excess. This applies especially in the case of very soluble nitrogenous fertilisers such as nitrate of soda.

ORGANIC MANURES VERSUS ARTIFICIAL FERTILISERS.

Artificial fertilisers are extremely efficient sources of plant foods, such as nitrogen, phosphate, potash, copper, magnesium, etc., and if properly used are at least equally as effective as organic manures. Quick-acting artificial fertilisers will often produce crop yields which are impossible with the less flexible organic manures.

Numerous fertiliser trials show that considerable latitude is permissible in the amounts and proportions of artificial fertilisers that may be applied without harming the plant or the soil. As our experience and skill increases there is no reason why artificial fertilisers should not produce vegetable crops as good or even better than organic manures, so long as the humus content of the soil is kept at a satisfactory level.

The addition of sufficient humus to the poor sandy soils encountered around Perth is very important for successful vegetable culture. One of the major advantages of the addition of organic matter is the improvement in soil structure, so that the soil becomes a better medium for plant growth. However, to raise the organic matter content of a soil appreciably, very large quantities of animal manure, vegetable waste, compost, green manure crops, etc., need to be applied.

ASSESSING THE VALUE OF ORGANIC MANURES.

Taking into account the points discussed previously, and the fact that we are concerned mainly with the supply of plant food to the immediate crop, the vegetable grower would assess the value of a particular organic manure along the following lines:—

Nitrogen.

Generally speaking, the vegetable grower pays primarily for a fairly concentrated form of nitrogen in his organic manures. The more concentrated forms

of organic nitrogen carry with them the following possible advantages: (1) lower transport costs; (2) ease of application; (3) suitable availability of the plant food. These conditions are fulfilled in such manures as blood and bone, dried blood, and high grade animal manures.

Potash.

Possibly his next consideration is the potash content of the organic manure. Normally where potash is deficient this can be readily remedied by applying sulphate or muriate of potash. When potash fertilisers are unprocurable the readily available potash content of the manure assumes greater importance, especially for crops like cabbages, tomatoes, cauliflowers, and potatoes. Manures supplying readily available potash, in varying degrees, include scouring works waste, barley combings, unleached wood ashes, urine, and high grade animal manures.

Phosphate.

Phosphate can usually be supplied most cheaply and in a more readily available form by the use of superphosphate. As a general rule the manurial value of most animal manures is improved by the addition of superphosphate.

Dehorning—Its Advantages and Practice.

R. R. RUTHERFORD, Farm Manager, Muresk Agricultural College.

To appreciate the value of dehorning one must consider fully the damage done daily by cattle which are horned and the resultant losses of revenue which follow such damage.

Bruising through close yarding may be said to be the main factor affecting horned beef cattle, and as a bruised carcase is worth so much less than one free from any blemishes the use of hornless cattle for this purpose cannot be too strongly recommended.

The fact that dairy cattle are allowed to remain horned may in many instances be—

(a) the cause of mammitis;

(b) the cause of lack of condition, inability to produce to a maximum and general nervousness which makes the animals difficult to handle.

Dehorned cattle on the other hand are tractable and can be close yarded in large numbers without damage. Young cows feed contentedly and quietly beside former boss cows of a herd. There is a marked decrease in udder injuries and resulting loss of production. Bulls are less dangerous to handle and finally the practice of dehorning gives uniformity of appearance to a herd. In fact it may be said that there is no factor which gives ample justification for the retention of horns in a dairy herd.

Cattle may be dehorned (a) as calves; (b) as mature animals.

(a) The practice of dehorning calves is one which can be followed when the complete herd is dehorned and is one which gives the minimum check to the animal. When the calf is 8-10 days old and the horn bud or button can be located, the hair should be clipped from round its base and vaseline rubbed over the clipped area to within one-eighth to a quarter of an inch of the bud. (This will

prevent the caustic soda spreading.) The button is then damped and rubbed over with a caustic soda stick held in a piece of thick brown paper. When a raw chafed appearance is produced, the operation is complete providing care has been taken to ensure that the caustic stick has made contact with the ring of skin one-eighth to a quarter of an inch around the base of the button. This is most important because it is in this area that the horn-producing tissue lies, and failure to treat it will result in recurring growths of horn which will need cutting off with a knife and re-treating when they appear.

When the operation is completed, turn the calf into a fair sized yard or paddock so that it is not interfered with by other calves. A scab will form where the bud was located and this will come away in due course leaving the animal hornless.

Avoid wet weather, which will cause the caustic soda to run and injure the calf.

Fig. 1.

(b) Where mature cattle require dehorning a strong bail is essential. For preference this should be located at the end of a race where the operator can move freely on both sides of the animal (see Fig. 1). A bucket of disinfectant (2 per cent. lysol solution) in which to place the dehorners after each operation, a nose grip and a length of rope to act as a breeching are all that is required. The animal is brought into the bail, the breeching is placed behind it and held as in Fig. 1, to keep the animal forward. An assistant grasps the animal by the nose and turns the head to one side as in Figs. 1 and 2. This allows the operator to place the dehorners over the uppermost horn with the flat side of the guillotine down, and open them sufficiently wide to take a ring of skin and hair one-quarter to one-half inch wide surrounding the base of the horn as in Fig. 2 (see diagram of correct cutting). One handle of the dehorners is rested on the operator's thighs (Fig. 2) leaving both hands free to apply leverage to the other handle and remove the horn (Fig. 1). In obstinate cases where the horn is particularly hard, the horn should be circled with the blades part clenched; this will cut a ring around the horn after which it will be found to come away freely. The assistant then reverses the head and the other horn is treated similarly. A little stockholm tar or boracic acid placed adjacent to the wound will act as a deterrent to flies.

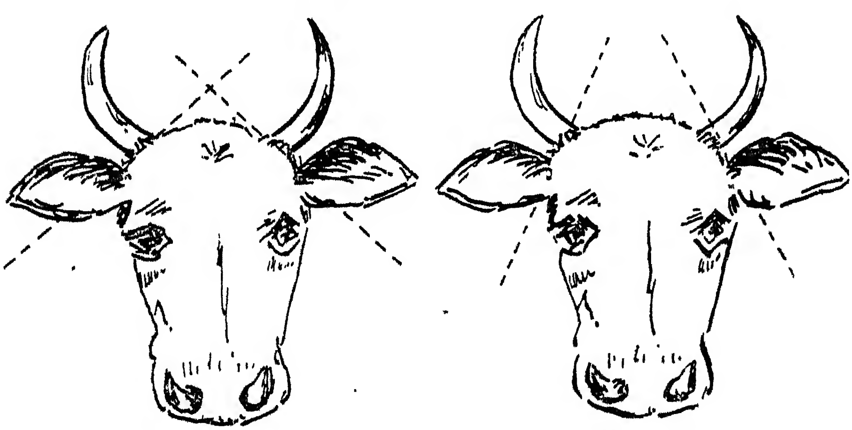
The animal may now be released.

Fig. 2.

Bleeding following the operation does not last long but obstinate cases may be plugged with cotton wool or seared with a hot iron. If it is possible, the operation should be carried out when the cows are dry, although cows in milk may be treated without sustained loss of production. It is advisable to avoid wet weather and periods when flies are bad.

Healing takes place rapidly and in this connection Muresk Agricultural College Guernsey herd may be cited. The herd was dehorned and four weeks later cows from it were shown successfully (completely healed), at the Perth Royal Show.

LINE OF CUTTING.



Correct. Incorrect.

Studies in Sheep Husbandry in W.A.

IV.—The Influence of a High Level of Prenatal Feeding in Lamb Production.

E. J. UNDERWOOD, F. L. SHIER, and H. G. CARISS.

In an experiment conducted during the 1941 season (Underwood and Shier, 1942), a group of 150 Border Leicester x Merino ewes, mated to Southdown rams, was grazed under poor nutritive conditions so that they were judged to little more than maintain their live weights throughout the last third of pregnancy. A similar group of ewes was grazed under the same conditions but received in addition a small "practical" supplement of ½ lb. wheaten grain per sheep per day for the last 6-8 weeks of pregnancy. The extra feeding given to the second group of ewes had no effect on the birth-weight of the lambs, either singles or twins, compared with those from the "unfed" ewes. There was also no effect on subsequent rate of growth of the lambs or on carcase quality, as determined by ordinary grading or by a series of external carcase measurements. The small supplement of grain, however, produced a highly significant reduction in losses of ewes and lambs before and after lambing. In addition it was found that in both groups the heavier lambs at birth grew faster than the lighter. On the average each increase of 1 lb. in birth-weight reduced the time taken for the lamb to reach a live-weight of 65-70 lbs. by approximately one week.

Both these positive findings were considered to be of such practical importance that further investigation was warranted. In particular it was felt that the influence of a much heavier level of prenatal feeding should be tried in order to find out how far it was possible by this means to raise the birth-weight of the lambs and how far any such increase in birth-weight would be reflected in a faster rate of growth and improved carcase quality. The importance to the lamb raiser of having his ewe and lamb losses reduced to a minimum and his lambs marketed as early as possible is so obvious as to need no further emphasis.

Accordingly, experiments were carried out at the Avondale Research Station, Beverley, during the 1942 and 1943 seasons with the object of obtaining further information on these and allied questions. The results of these experiments are described below.

EXPERIMENTAL PROCEDURE.

The procedure was essentially similar to that used in the 1941 experiment (Underwood and Shier, 1942). In both 1942 and 1943 all the ewes were mated with rams raddled on the brisket and the marked (i.e., mated) ewes taken off twice weekly and the service dates recorded. From these, two even groups, all due to lamb within a restricted period, were selected and run as one flock until the differential feeding treatments of the two groups commenced. In each year any ewes which did not lamb during the expected period were eliminated from the experiment. The ewes were inspected twice daily at lambing and all the lambs weighed to the nearest ounce, eartagged and recorded. Thereafter the ewes and lambs from both groups were run as one flock. The lambs were weighed at frequent intervals until they reached a live-weight of 65 lbs. All lambs were tailed and the males castrated when 3-5 weeks old.

FEEDING AND GRAZING DETAILS.

1942 *Season.*

It was originally decided to provide the ewes of the fed group with a heavy supplementary ration of oats and linseed nuts during the prenatal period. The

abnormally early autumn rains with the resultant early green feed, however, necessitated a modification of this plan. It was decided to exploit the earliness of the season by grazing the fed group on an early sown crop of barley, which supplied ample quantities of high quality feed. The control ewes were grazed on a restricted area carrying mainly sparse Wild Geranium (*Erodium botrys*) and Barley Grass (*Hordeum maritinum*). The ewes of the fed group made large weight gains on the green barley, whilst the control ewes did little more than maintain their live-weights over the prenatal period of differential treatment (Table I.).

1943 *Season.*

Early opening rains were again experienced, but it was possible to arrange the paddocking so that the basal grazing of geranium and barley grass, etc., although green, was restricted in quantity for both groups. The ewes of the fed group were given a supplement of ½ lb. wheat plus ½ lb. linseed nuts per head per day for the last 7-9 weeks of pregnancy. The groups were alternated between the two paddocks weekly. Although the grazing in the two paddocks was similar in character at the commencement of the feeding treatments, it apparently became less in one during the experiment, as the fed group, in spite of the supplementary feeding given, lost in weight during the period 4th May, 1943 to 18th May, 1943. This was in all probability the reason for the loss of three ewes from pregnancy toxaemia in the fed group. During the last fortnight both groups received a supplement of ½ lb. of cereal hay per head per day to help make good the diminishing paddock grazing. The mean weights of the ewes in the two groups are shown in Table I. The control ewes did not quite maintain their live-weights over the period. The fed group made an average gain of 20 lbs. during the feeding period, compared with about 30 lbs. for the similar period in the previous year's experiment.

TABLE I.

Live Weights of Ewes (number of Ewes in brackets).

——	6-4-42.	28-4-42*.	12-5-42.	26-5-42.	5-6-42†.	16-6-42.	24-6-42.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Controls	122 (167)	119 (167)	119 (167)	120 (167)	126 (160)	113 (118)	117 (42)
Fed Group	121 (173)	119 (173)	125 (173)	136 (173)	142 (173)	152 (132)	151 (47)
——	6-4-43.	20-4-43*.	4-5-43.	18-5-43†.	2-6-43.		
	lbs.	lbs.	lbs.	lbs.	lbs.		
Controls	118 (183)	114 (183)	113 (181)	113 (169)	111 (83)		
Fed Group	117 (185)	115 (185)	125 (183)	124 (181)	135 (92)		

* Differential feeding commenced. † Lambing commenced 8th June, 1942 and 20th May, 1943.

In both 1942 and 1943 the ewes and lambs from each group were grazed on abundant green crops and pasture immediately after lambing.

RESULTS.

Effect of Feeding Treatment on Ewe and Lamb Losses.

All losses of ewes and lambs from the experimental groups were recorded from the beginning of the differential feeding treatment, i.e., 7-9 weeks prior to lambing, until the tailing of the lambs at 3-5 weeks of age. The combined results for 1942 and 1943 are presented in Table II.

TABLE II
Losses of Ewes and Lambs 1942 and 1943

Treatment.	Total No. of Ewes.	Ewe Losses			Lamb Losses			Total No. Lambs Tagged.
		Pregnancy Toxaemia	Other Causes	Total.	At or before Birth	Shortly after Birth.	Total.	
Controls	350	26	2	28	*60	11	71	328
Fed Groups	358	3	1	4	*14	6	20	395

* Including twins and singles lost with ewes dying from pregnancy toxaemia.

Statistical analysis of these results shows that the extra food supplied to the ewes during the last third of pregnancy has had a highly significant effect (P <0.01) in reducing losses of both ewes and lambs.

Effect of Feeding Treatment on Birth-weight and Growth-rate of Lambs.

The mean birth-weights of the lambs and the number of days taken to reach a live-weight of 65 lbs. are presented in Table III. It should be noted that the mean birth-weights are for all lambs born alive. Some of these lambs died before reaching the required live-weight, some were lost by accident or for other experimental purposes or, as in the case of the twins, failed to reach 65 lbs. live-weight within reasonable time limits.

TABLE III.
Birth-Weight (lbs.) and Growth-Rate of Lambs.
(Numbers in brackets.)

Group.	1942.		1943.	
	Mean Birth-Weight.	Age at 65 lbs. live weight.	Mean Birth-Weight.	Age at 65 lbs. live weight.
	lbs.	days.	lbs.	days.
Singles—				
Controls Wethers	9·9 (65)	90 (61)	9·1 (81)	88 (77)
Controls Ewes	9·2 (67)	96 (58)	8·6 (73)	103 (69)
Fed Wethers	10·9 (70)	85 (67)	10·8 (86)	86 (80)
Fed Ewes	10·1 (64)	93 (60)	10·3 (82)	94 (81)
Mean of Controls (Ewes and Wethers)	9·5 (132)	93 (119)	8·9 (154)	95 (146)
Mean of Fed (Ewes and Wethers)	10·5 (134)	89 (127)	10·5 (168)	90 (161)
Twins—				
Controls Wethers	7·4 (17)	107 (9)	8·1 (7)	119 (5)
Controls Ewes	6·4 (15)	114 (3)	6·9 (3)	137 (2)
Fed Wethers	9·8 (40)	99 (35)	9·7 (6)	99 (3)
Fed Ewes	9·2 (35)	104 (25)	9·1 (12)	117 (9)
Mean of Controls (Ewes and Wethers)	6·9 (32)	109 (12)	7·8 (10)	124 (7)
Mean of Fed (Ewes and Wethers)	9·5 (75)	101 (60)	9·3 (18)	112 (12)

Statistical analysis of the results from which Table III. was constructed showed that there was a definite effect on birth-weight and growth-rate due to sex. The male lambs were significantly (P <0.01) heavier at birth than the female. The magnitude of the difference, averaging treatments, was small, however, being 5 per cent. in 1942 and 7.5 per cent. in 1943. The male lambs also grew significantly (P $<.01$) faster than the female. The difference in this case was somewhat greater, being 8 per cent. in 1942 and 10 per cent. in 1943.

There was also a highly significant (P <0.01) effect from the feeding treatment on birth-weight and growth-rate in both singles and twins. The increase in birth-weight of the single lambs from the "fed" ewes was 10 per cent. in 1942

and 18 per cent. in 1943. In actual weights this represented a mean increase of 1 lb. in 1942 and 1.6 lb. in 1943. The effect on the twin lambs was remarkable. In 1942 the twin lambs from the "fed" ewes averaged 2.6 lbs. heavier at birth than those from the control ewes. In both years it should be noted that the heavy prenatal feeding has resulted in the production of twin lambs as heavy at birth as the single lambs from the control ewes.

The effect of the feeding treatment on growth-rates, as revealed by the number of days taken to reach 65 lbs. live-weight, is also highly significant ($P < .01$) but the effect is smaller than that on birth-weight. The single lambs from the fed ewes grew 3.5 per cent. faster than the controls in 1942 and 4.2 per cent. in 1943. This represented an average decrease of four days in 1942 and five days in 1943. The effect on the twins is more marked especially in the latter year, when both the wether and ewe twin lambs from the "fed" ewes reached a live-weight of 65 lbs. almost three weeks quicker than the control twins.

The Influence of Birth-weight on Rate of Growth.

The number of days taken by the single lambs to reach 65 lbs. live-weight are grouped according to birth-weight in Table IV. The results for the two years 1942 and 1943 are so similar that they were combined for each birth-weight group.

TABLE IV.

Birth-Weight and Rate of Growth.

Single Lambs only (numbers in brackets).

Birth-Weight (lbs.).		Age at 65 lbs. live-weight. Wethers.	Age at 65 lbs. live-weight. Ewes.	Age at 65 lbs. live-weight. Wethers.	Age at 65 lbs. live-weight. Ewes.
		days.	days.	days.	days.
Below 8	Controls	98 (10)	107 (28)	98 (11)	107 (29)
	Feds	95 (1)	112 (1)		
8-9	Controls	93 (35)	104 (40)	94 (40)	103 (59)
	Feds	95 (5)	99 (19)		
9-10	Controls	88 (52)	95 (50)	89 (88)	96 (95)
	Feds	91 (36)	98 (45)		
10-11	Controls	85 (29)	90 (6)	86 (72)	92 (52)
	Feds	86 (43)	92 (46)		
11-12	Controls	81 (13)	86 (2)	82 (54)	90 (24)
	Feds	83 (41)	90 (22)		
Over 12	Controls	74 (1)	69 (1)	76 (22)	81 (10)
	Feds	76 (21)	82 (9)		

The importance of birth-weight in determining the rate of growth of both male and female lambs is very apparent. There is a steady increase in rate of growth with increase in birth-weight in the "fed" and the "control" lambs, with a difference of about three weeks in time taken to reach "maturity" between the heaviest and the lightest groups at birth. The regression coefficients were determined for each of the treatment-combinations and the effect of birth-weight on growth-rate was found to be highly significant in each year. For each 1 lb. increase in birth-weight there was found to be a decrease in time taken to reach 65 lbs. live-weight of 4.5 days in 1942 and five days in 1943.

No significant difference due to the feeding treatment was found in either year. In other words the lambs from the "fed" ewes have grown no faster than those *of the same birth-weight* from the control ewes. It is apparent that the

effect of the heavy prenatal feeding in increasing the growth-rate of the lambs can be wholly accounted for by the effect on birth-weight. This is surprising in view of the claims of Hammond (1932), Verges (1939) and Thomson and Fraser (1939), that prenatal feeding increases the milk yield of the ewes and of Ritzman (1917), Neidig and Iddings (1919), Hammond (1932 and 1940) and Bonsma (1939) that the early growth of the lamb is largely influenced by the milk yield of the mother.

The results for the twins are not included in Table IV. owing to the small numbers involved in the various birth-weight groups. Inspection of the data, however, reveals no obvious advantage in favour of those from the "fed" ewes, other than that due to their higher birth-weight. It would be expected that any effect on milk yield would be particularly noticeable with twins whose slower rate of growth compared with singles is believed to be due principally to the smaller amount of milk available per lamb. Support for this is provided by the fact that the few twin lambs reared as singles grew at about the same rate as the lambs of the same birth-weight born as singles and by the fact that the "fed" twins grew much more slowly than the "control" singles, although they were of similar average birth-weight.

It is also clear from Table IV. that the male lambs have grown faster than the females, independently of their heavier birth-weight. This contrasts with the results of Bonsma (1939) who found the significant difference in growth rate in favour of male lambs, compared with females, to be accounted for by the difference in birth-weight. On a basis of equal birth-weights the differences were found by this worker to be non-significant.

External Carcase Measurements.

A method of estimating carcase quality by means of a series of internal and external measurements has been used by Palsson (1939). A number of these external measurements and also the weight, length and minimum circumference of the left fore cannon-bone (efficient indices of the proportion of bone in the carcase) were used by the authors (Underwood and Shier, 1942) in their previous study on prenatal feeding and lamb growth. Similar measurements were made on an extended series of single and twin lambs from the 1942 experiment.

No good purpose would be served by detailing these results here. All the measurements taken were practically identical with those obtained from the single lambs in the previous year. No significant difference in conformation of carcase or proportion of bone, as revealed by these measurements, was obtained between the single lambs of the "fed" or the control groups; between the single or twin lambs in either groups; or between the twins of the "fed" and the twins of the control group, in spite of the significantly faster growth-rate of the former in each case. Apparently within the limits of time taken to reach a 65 lb. live-weight found in these experiments rate of growth is not an important factor in determining carcase quality.

Relation between Weight of Ewe and Birth-weight of Lamb.

The very large range in live-weight of the ewes raised the question of the relation of this weight to the birth-weight of the lamb. Accordingly, they were divided into 10 weight groups, each differing by 5 lbs., and the mean birth-weights of the male and female lambs from the "fed" and "control" ewes calculated for each of these weight groups. The results for 1942 and 1943 combined are presented in Table V.

TABLE V.

Ewe Weight and Birth-Weight of Lamb.*

Single Lambs only (numbers in brackets).

—	90–95.	96–100.	101–105.	106–110.	111–115.	116–120.	121–125.	126–130.	131–135.	136–145.
'ed—										
Wethers	10·1 (3)	10·2 (8)	10·5 (14)	11·3 (21)	10·5 (19)	11·1 (19)	10·6 (19)	10·8 (18)	11·1 (13)	10·8 (8)
Ewes	9·7 (6)	10·0 (7)	10·1 (17)	10·4 (12)	10·5 (23)	9·9 (25)	10·2 (16)	10·2 (16)	10·8 (10)	10·5 (10)
'ontrol—										
Wethers	8·4 (6)	8·9 (10)	8·9 (11)	9·6 (10)	9·3 (11)	9·6 (23)	9·7 (29)	9·8 (16)	10·2 (10)	9·6 (16)
Ewes	8·0 (7)	8·2 (17)	9·2 (10)	8·8 (11)	8·6 (21)	9·6 (21)	9·2 (15)	9·0 (16)	8·6 (14)	8·5 (7)

* Ewe weights were taken as at 28th April, 1942, and 6th April, 1943, *prior* to the start of the differential feeding treatment and after several months under identical grazing conditions. The ewes had been 2–3 months pregnant on these dates.

The ewe weights were all taken at the commencement of the differential feeding treatment in each year. At this time the ewes (which were all mature animals aged 3½ to 5½ years) were 2-3 months pregnant and had all been under the same grazing conditions for several months. As a flock they can best be described as in "forward store" condition. It is realised that to a certain extent these live-weight differences can be ascribed to differences in degrees of fatness, but the numbers involved and the long period under the same nutritive conditions prior to weighing make it appear very unlikely that degree of fatness is a significant factor. The live-weights can therefore be taken as a reasonable index of the size of the ewe.

Inspection of Table V reveals that there is a tendency for the heavier ewes to produce very slightly heavier lambs. Statistical analysis of the data by the determination of the regression coefficients showed that there was no significant effect of ewe weight on lamb birth-weight *over the whole weight range,* for either the control ewe lambs or the fed ram lambs. In the case of the other two groups of lambs a significant effect was found but the mean increase in birth-weight was only 0.16 lb. for each 10 lb. increase in live-weight of the ewe.

Construction of a dot diagram indicated, however, that up to a ewe weight of between 105 and 110 lbs., there might be a more definite effect. Determinations of the regression coefficients from 90 to 110 lbs. ewe weights revealed a highly significant effect in three of the four lamb classes, i.e., the "fed" rams and the "control" rams and ewes. The mean increase in birth-weight of these three classes was 0.50, 0.63 and 0.85 respectively for each increase of 10 lb. in the weight of the ewe. For the heavier ewes, i.e., from 110 to 145 lbs. live-weight there was no significant effect for any of the four classes of lambs.

These results are not in conformity with those of Bonsma (1939) or Donald and McLean (1935). Bonsma found, with merino ewes mated to rams of a number of different breeds, a highly significant positive correlation between ewe weight and birth-weight of the lamb. The mean increase in birth-weight over a weight range of 55 to 120 lbs. of the ewes was very close to 0.72 lb. for every 10 lb. increase in live-weight of the ewes. Donald and McLean found, with a mixture of English Leicester ewes mated to rams of the same breed and Romney cross ewes mated to Southdown rams, about 1 lb. increase in lamb birth-weight for every 10-15 lbs. increase in ewe weight over a weight range of 65 to 160 lbs. It should be pointed out, however, that in the case of these latter workers, most of the ewes of smaller size were of an entirely different breed from those of larger size.

There are two other considerations which deserve mention before comparing our results with those of Bonsma and of Donald and McLean. Their ewe-weights were taken in both cases immediately following lambing and would therefore reflect nutritive conditions prior to lambing, themselves capable of influencing the birth-weight of the lamb, as our 1942 and 1943 experiments show. Also the lambs of these workers were all either first cross* or pure bred, whereas ours were all second cross lambs. A much higher degree of individual variation would be expected in such second cross lambs. Extreme individual variability in birth-weight and growth-rate of lambs, from ewes of the same weight or prenatal feeding treatment, was a striking characteristic of our data, necessitating the use of large numbers to reveal significant group differences. Individual variation of this nature points strongly to the influence of genetic factors in the experimental ewes, other than that indicated by their size, which affect the birth-weight (and growth-rate) of the lamb.

* Author's Note.—The N.Z. Romney cross ewes cannot be regarded as crossbreds in the true sense since although originally merino X Romney Marsh they have been repeatedly bred back to the Romney.

DISCUSSION.

Consideration of the results of the present experiments as a whole, together with those of the 1941 experiment, enables a clearer picture of the factors governing the production of high quality lambs to be painted, but still leave a number of important details to be filled in. In 1941 the "fed" ewes received only a very small supplement during late pregnancy and the only effect of the treatment was to produce a striking reduction in losses of ewes and lambs at or near lambing time, with no effect on birth-weight or growth-rate of the lambs. In 1942, and to a slightly smaller extent in 1943, the "fed" ewes were subjected to a much higher level of nutrition during late pregnancy and made considerable weight gains during this time. As would be expected there was once more a striking reduction in losses of ewes and lambs at or near lambing time. If this were the only effect of the heavier and more costly feeding treatment it is obvious that the only type of supplementary feeding which could be recommended from the practical point of view would be the smallest amount necessary to prevent such losses or reduce them to a minimum. From the results of the feeding of as little as ½ lb. of wheat per ewe per day for the last six weeks of pregnancy in 1941 it is apparent that the amount required must be very small and highly economic under average seasonal conditions in the export lamb producing areas in W.A.

However, the heavier prenatal feeding of the ewes in 1942 and 1943 produced, in addition, a significant increase in birth-weight of the lambs and a faster growth-rate, as measured by the number of days taken to reach a live-weight of 65 lbs. The effect on birth-weight of the single lambs was quite definite and highly significant in each year, but the effect on the twins was very marked. The mean birth-weight of the twin lambs from the "fed" ewes was actually raised to that of the single lambs from the control ewes. The significance of high birth-weight lies in the high positive correlation between birth-weight and rate of growth. This was found in the 1941 experiment and has been amply confirmed by the 1942 and 1943 experiments as shown in Table IV.

In 1941 each increase of 1 lb. in birth-weight reduced the time taken to reach a live-weight of 65-70 lbs. by about seven days on the average. In 1942 and 1943 the reduction, for each 1 lb. increase in birth-weight, was 4.5 and five days. As a result the singles from the "fed" ewes in 1942 reached "maturity" only four days earlier than the controls and in 1943 only five days earlier than the controls (see Table III.). This difference is so small that from this point of view very heavy prenatal feeding can hardly be justified. With the twins the reduction in time taken to reach "maturity" due to the feeding treatment was greater, especially in 1943, as would be expected from the greater effect on birth-weight, but the numbers of twins reaching 65 lbs. live-weight within a reasonable period, taking into account normal seasonal limitations, are ordinarily small in flocks of this type. Recommendations to feed heavily, based upon the probable improved performance of twins, would therefore seem to be unwarranted.

A point of considerable interest, apparent from Table IV., is that single lambs of the same birth-weight from the "fed" and the control groups have taken approximately the same time to reach 65 lbs. live-weight. In other words, the increased growth rate due to the prenatal feeding treatment, discussed in the previous paragraph, is entirely due to the increased birth-weight. This does not support the claims of other workers that raising the plane of nutrition of the ewe before lambing not only increases the weight and vigour of the lambs at birth, but produces an additional increase in growth-rate due to a stimulation of the milk yield of the mother. Examination of several of the ewes from the control group in the 1943 experiment indicated that these ewes had a very poor milk supply, at least

in the first 10 days of lactation, compared with the well fed ewes. If the very few examined were representative of the group as a whole, as seems most likely, then it is obvious that either the control ewes were able to overcome their early handicap with respect to lactation and later produce as much milk as the "fed" ewes, or the growth of the control lambs, under the conditions of these experiments, was not limited by the milk supply of the mother. Much more extensive milk yield studies, together with details of the growth of the lambs in the first few weeks of life, under high and low prenatal feeding treatments of the mother, are necessary to throw further light on this matter. Such studies are contemplated in the coming season.

A further important point to which attention was drawn in the published account of the 1941 experiment (Underwood and Shier, 1942), is the great variation in growth-rate of lambs of the same birth-weight in different seasons. It should be pointed out that these are of identical breeding, at least in the last three years' experiments, and in addition, all ewes and lambs from the day of lambing are run under apparently ideal nutritive conditions, i.e., they are grazed on ample quantities of young, green cereal crops, low in fibre and high in protein and other dietary essentials. Yet in 1941 the male and female lambs of 8-9 lbs. birth-weight took 118 and 130 days respectively to reach 65 lbs. live-weight, compared with 94 and 101 days for the lambs of the same birth-weight in 1942 and 92 and 102 days in 1943. And again in 1941 the male and female lambs of 10-11 lbs. birth-weight took 109 and 113 days respectively to reach maturity compared with 86 and 90 days in 1942 and 85 and 93 days in 1943. These seasonal differences are so large as to suggest that environmental conditions, other than nutrition, *after* lambing, as well as the level of nutrition *before* lambing, may be of extreme importance in determining the rate of growth of lambs. Temperature and the number of wet days immediately present themselves as of likely significance.

An indication that a succession of wet, cold days may exert a considerable influence on the growth of lambs was obtained in 1943. Thus on two occasions following a wet, cold period it was noticed that the weight gains of the lambs was smaller than during succeeding periods of fine, sunny weather. It seems reasonable to deduce from this that if the wet, cold weather had lasted much longer, as happens in some seasons, the overall rate of growth of the lambs would have been retarded and the length of time taken to reach 65 lbs. live-weight have approached more nearly that of the 1941 season. An analysis of the climatic conditions in a succession of seasons, for which lamb growth data are available, is being attempted and will be published with the results of next season's studies.

SUMMARY.

Experiments carried out at the Avondale Research Station, Beverley, with 340 Border Leicester x Merino ewes mated to Southdown rams in 1942, and 370 similar ewes in 1943, are described.

The ewes were divided into two even groups in both years. One group in each year (Control Group) was run on a restricted area of grazing during the last two months of pregnancy, so that the mean live-weight of the ewes was just maintained. During the same period in 1942 the other group (Fed Group) was grazed on ample young green barley so that a mean live-weight of increase of about 30 lbs. was produced. In 1943 the Fed Group received a supplement of ½ lb. wheat and ½ lbs. linseed nuts per ewe per day which produced a mean live-weight increase over the last two months of pregnancy of about 20 lbs.

It was found that the high levels of prenatal feeding brought about:—

(i) a highly significant reduction in losses of ewes from pregnancy toxaemia and of lambs at or near lambing time.

(ii) a highly significant increase in birth-weight and growth rate of both single and twin lambs. The effect on growth rate was much smaller than that on birth-weight;

(iii) no improvement in carcase weight or quality, as revealed by the grading returns and a number of external carcase measurements.

It was also found that:—

(i) the heavier lambs at birth grew significantly faster than the lighter. On the average each increase of 1 lb. in birth-weight of the singles reduced the time taken to reach 65 lbs. live-weight by 4.5-5 days;

(ii) the increased growth rate of the lambs from the fed groups could be wholly accounted for by the increase in birth-weight;

(iii) the male lambs were significantly heavier at birth than the female and grew faster, even when considered on the same birth weight basis;

(iv) there was no relation between rate of growth and carcase weight or quality;

(v) up to about 110 lbs. live-weight the heavier ewes produced significantly heavier lambs at birth but above this weight there was no association between the weight of the ewe and the weight of the lamb.

The significance of these findings and those of the 1941 experiment is discussed and the conclusion reached that very high levels of prenatal feeding are unlikely to be economic, since the increase in growth-rate from such treatment is not, on the present evidence, very great and the losses of ewes and lambs can be equally prevented by a small supplement of grain.

Attention is drawn to the great variation in growth-rate of lambs in different seasons and the suggestion made that climatic conditions after lambing may have a marked effect on lamb growth.

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Black Rot of Cabbage, Cauliflower and Related Plants.

W. P. CASS SMITH, Plant Pathologist.

Black rot is a common and serious disease which has been recorded from practically all countries where crucifers are grown. The disease is most prevalent here on cabbage and cauliflower, but it may also affect other plants belonging to the family *Cruciferae* including—brussel sprout, broccoli, kohlrabi, turnip, swede, radish, flowering stock, and a number of weeds, such as mustard and wild radish. During the winter months, black rot is usually of little consequence, but during warm wet weather it may be extremely destructive, especially when it becomes established early during the growing season.

Plate 1.

Cabbage leaf showing symptoms of black rot.

Infection generally occurs through waterpores at the leaf margin, but it may also take place through wounds made by biting insects. After infection the organism advances through the vascular strands into the leaf stalk and main stem, and the invaded tissues are blackened and killed. Note blackening of small affected leaf veins, and of the vascular strands in the leaf stalk. (See cross-section relatively enlarged.)

In March, April and May, 1943, weather conditions were extremely favourable for the development of the disease and outbreaks occurred in cabbage crops in several districts, including Osborne Park, Spearwood, Balcatta and Wanneroo. Serious losses were caused on this occasion, which in some cases amounted to total crop failure. These outbreaks were largely attributed to the planting of contaminated seed and there is no doubt that by paying more attention to relatively simple control measures, growers could to a great extent have prevented such disastrous losses.

CAUSE.

Black rot is a bacterial disease caused by *Bacterium campestre* (Pam.) E.F.S. These minute bacterial organisms are generally introduced into new areas with seed which has been harvested from diseased plants, and to a lesser extent by introduced seedlings, or animal manures or composts, containing diseased plant remains. Once the disease is established, the bacteria are spread about chiefly by spattering rain or water from sprinklers, biting insects, and surface wash. They are able to swim freely in water and if they lodge near the waterpores on the leaf margins where water collects, or on insect injuries where sap exudes, they cause infection. After infection they invade the plant tissue until the veins are reached and their further progress is mainly confined to the water conducting strands in which they rapidly multiply and spread.

SYMPTOMS.

Plants may be affected with the disease at any stage of growth. Usually the first obvious sign of the disease is the blackening of some of the smaller veins at the leaf margin, and later the affected leaf tissues become brown and wilted. Similar symptoms may also be seen in the neighbourhood of wounds caused by biting insects. The further progress of the disease is inward and downward to the stem through the water-conducting strands and it can usually be traced in the smaller veins by their black discolouration. In the thick leaf stalks and main stem however, this symptom is generally visible only on cross-sectioning

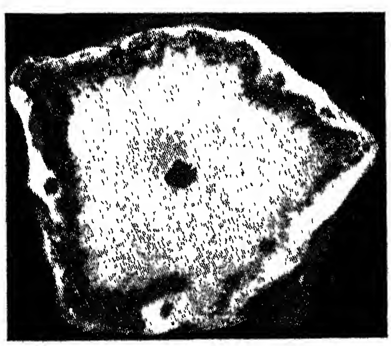

Plate 2.
Cross section of cauliflower stem showing typical black rot invasion. After Shropshire and Kadow.

(Plates 1 and 2). Once the main stem is invaded the organism progresses up or down, subsequently invading younger or older leaves, which yellow and drop prematurely. Plants infected at an early stage frequently make "one sided" growth (Plate 3) or are dwarfed and heading is sometimes prevented. Affected leaves soon drop and badly diseased plants often have a long bare stalk with a small head or

tuft of leaves at the top. Black rot alone does not cause a soft rot, but frequently secondary soft rot bacteria enter the invaded tissues causing a slimy head decay and stump rot.

Except in the case of turnip, swede and radish, the disease is confined to the above ground parts. However, the storage organs of these and similar crucifers with fleshy roots may be affected below ground with a dry rot, and this is frequently followed by soft rot (Walker, 1938).

CONTRIBUTING CONDITIONS.

The disease is generally initiated either from black rot bacteria introduced with the seed or present in the soil. Some affected seedlings may be killed outright, but others survive and from these the disease is primarily spread to other healthy plants.

In transplanted crops such as cabbage and cauliflower, black rot usually commences in the seed-bed where plants are crowded, and here an early spread of the disease is greatly favoured. Splashing water from sprinklers, or rain, is probably the most important means of dissemination for it has been shown (Walker, 1934) that in seed-beds protected from rain and watered by furrow irrigation, the spread of black rot is checked very considerably. During our warm dry summer months, sprinklers are commonly used to water cabbage or cauliflower seed-beds and thus ideal conditions are provided for the spread of the disease.

Plate 3.
Cabbage plant showing "one sided" growth resulting from invasion of the stem on one side only, at an early stage.

The duration of the seed-bed period may thus be a matter of importance also, unless precautions are taken, because the longer the plants remain in the beds before they are transplanted the greater is the liability to widespread infection. For economy of labour and also to obtain a hardy type of seedling which transplants well, growers sometimes retain cabbage seed-beds for lengthy periods in summer to provide seedlings for two or more plantings. Quite apart from the

doubtful advantages of this practice, it has been noticed in these circumstances, that whereas the first crop contained few diseased plants, later crops and any plants remaining in the seed-bed were often badly diseased.

In the seed-bed, symptoms of black rot often escape notice for infected lower leaves usually drop off. However, such plants are affected internally when transplanted, and subsequently when they develop typical symptoms in the field, growers generally believe the outbreak is of recent origin.

The severity of the disease in the field and the time taken for symptoms to appear after transplanting varies considerably. During warm wet periods when plants are turgid and making vigorous growth the disease progresses rapidly, and secondary infections are more numerous, but with less favourable conditions the development of the disease is slower and its extent is lessened.

At the present time when insecticides are often in short supply, biting insects are probably more prevalent than usual. Insects of this kind transmit the black rot bacteria and also cause injuries through which infection may take place (Plate 4), and so the disease may reasonably be expected to increase above its normal amount, unless adequate steps are taken to prevent its occurrence.

Plate 4.
Biting insects transmit black rot bacteria, and also cause injuries through which infection may take place. Note insect wound in the black rot-affected area of this cabbage seedling leaf.

Attention to hygiene is also very necessary. All too frequently diseased plants are left lying in the field or seed-bed or they are dumped on the manure heap to rot. The organism may be carried over from year to year by diseased plant refuse and its disposal either by fire, or deep burial, in land which will not be cropped to crucifers for two to three years, is obviously important.

Continuous cropping of the land with crucifers will in the long run prove very bad economy, for this practice encourages other parasites in addition to black rot.

CONTROL.

1. Unless the seed is known to be disease-free it should be disinfected before planting with the hot water treatment.* This measure is especially important during war time when seed of unknown origin must often be used.

2. Locate the seed-bed well away from the area in which the transplants will be set, either on new soil, or on land which has not grown cruciferous crops for several years.

If any doubt exists as to the freedom of the ground from disease, sterilise the soil with formalin.† Eradicate weed hosts such as mustard, wild radish, etc., from the vicinity.

3. Since water from overhead sprinklers disseminates the causal organism, avoid wetting the foliage in the seed-bed, either by planting on moist soil, or by furrow irrigation between the rows.

4. Adopt a rotation so that cruciferous crops are only grown once every two to three years on the same ground.

5. Eliminate biting insects as much as possible by the use of appropriate insecticides, and pay strict attention to hygiene practices.

* HOT WATER TREATMENT.

To disinfect cruciferous seeds from black rot, and incidentally from black leg also, immerse the seed in hot water (122° F.) for 25 minutes for cabbage and 15 minutes for others. To ensure uniform temperature conditions during the steep, a large volume of water in proportion to seed should be used, e.g., ¼ to ½ lb. per four gallons. A suitable container, such as a kerosene tin fitted with a lid in which two holes have been bored, is nearly filled with water at the required temperature and well insulated with straw, chaff or bran, etc., either in a box, or hole in the ground. The seed, tied loosely in a cheesecloth or muslin bag, is then suspended in the hot water and the tie passed through a hole in the lid. Through the other hole, an accurate Fahrenheit thermometer is inserted. During treatment the seed should be well agitated, but care should be taken to avoid wetting the insulating material. Boiling water should also be on hand to maintain the temperature as required. After treatment dry the seed as rapidly as possible by spreading it out thinly in the shade and stir it to promote air circulation. The reduction in germinable capacity of good quality seed is small when the hot water treatment is carefully applied according to directions. Weak seed should not be treated, therefore, if the quality is doubtful, a trial sample should first be tested.

† SOIL STERILISATION WITH FORMALIN.

To sterilise soil with formalin make up a 2 per cent. solution by adding one gallon of commercial formalin to 49 gallons of water. This solution is applied with a watering can to the soil, which should previously have been well loosened up, at the rate of about one-half to one and one-half gallons of the solution to the square foot. The heavier the soil, the more needs to be used. The treated soil is then smoothed down and covered with bags moistened with the formalin solution, and left for several days. Forty-eight hours is usually enough, but no harm will be done if the covers are left on for a longer period. The bags are then removed and the soil thoroughly stirred with implements previously sterilised in steam, fire, boiling water, or formalin so as to let out the fumes. The stirring process should be repeated several times during the next ten days or a fortnight, after which the seeds may be safely sown. This treatment has been used many times in this State with great success.

LITERATURE.

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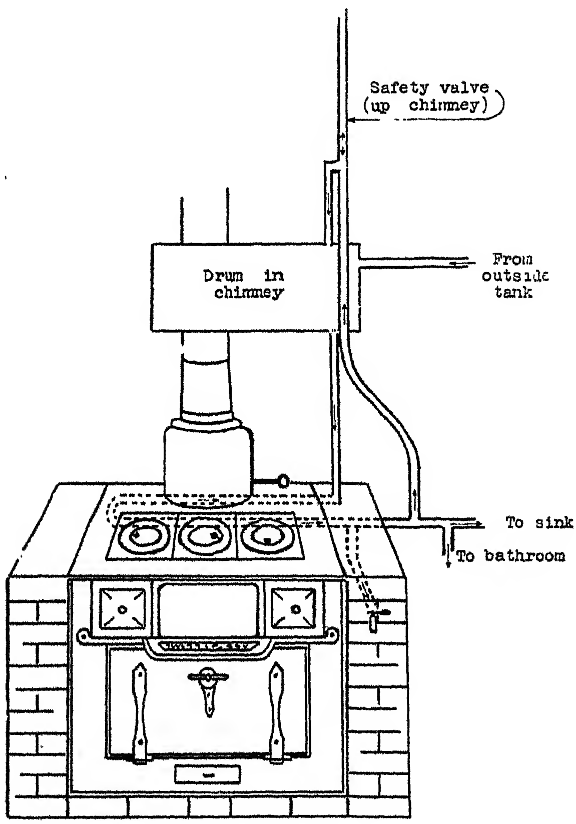
Hot Water Unit for Country Homes.

F. V. KNAPP, Agricultural Adviser.

There is a considerable demand for hot water in country homes, for besides washing up, baths, etc., hot water is required for the washing and scalding of milking utensils and separator parts and in general insufficient water is provided by kettles and saucepans for the proper cleansing of such items. Most farm kitchens have a fire burning for the greater part of the day and the following unit, as designed and installed by Mr. E. Chester of Cleary, can be installed in such kitchens with very little expense or labour.

Requirements.

(a) A 100-gallon tank mounted on a stand at least twelve feet high.
(b) A drum of approximately 12-gallon capacity (a petrol drum serves well).
(c) Piping (galvanised or black) ¾in. or 1in. diameter. Length will depend on conditions.



Procedure.

The tank is placed on a stand (either in the ceiling of the home or adjacent to the house) and if a water scheme is available, the filling is controlled by a ball cock, whilst where no scheme is available the water must be pumped into the tank, and in such cases the head of water may also be used for a bathroom shower. Care should be taken that the tank does not become empty.

The drum is placed either horizontally or vertically in the chimney of the kitchen fireplace, just above the mantelpiece where it will be out of sight; arrangements should be made so that the drum can be easily removed, if necessary.

The piping is connected as follows (see diagram):—One pipe from the bottom of the outside tank to the centre of the drum. A second pipe from the bottom of the drum in through the side of the firebox of the stove (remove a few bricks from the hob and the side of the firebox can easily be cut, as it is usually only 16-gauge iron) across the firebox (near the back) and out again through the same side. In stoves with a large firebox, the pipe may go around the firebox or across it a couple of times to give greater heating surface. It is preferable to have one continuous piece of pipe in the fire-box, but jointed bends will serve. After leaving the firebox the pipe is divided into four by means of sockets—one of these goes to a tap in the hob, another to the kitchen sink, the third to the bathroom, whilst the fourth returns to the top of the drum and then continues on up the chimney, to a height above the level in the tank, to act as a safety valve.

All sockets in contact with the hot water should be soldered to prevent leaking and after prolonged use the washer in the tap in the hob will need replacing.

Galvanised or black piping in the firebox gives very good service although copper piping, if procurable, would be more suitable.

The bathroom should not be too far away from the kitchen as the water cools off somewhat whilst travelling the distance. However this can be overcome to a large extent by lagging with asbestos rope.

Such a system supplies boiling water at the hob and very hot water at the kitchen sink, in quantity, so long as the fire is alight and not too great a drain is made on it. The water in the drum remains hot for a long period after the fire is out and this period can be increased by suitable insulation of the drum and pipes.

Thanks are due to Mr. Chester for the explanation of the scheme and permission to publish it.

Vitamin A and other Vitamins in the Nutrition of Farm Animals.

E. J. UNDERWOOD, Animal Nutrition Officer.

It is now generally realised that a large array of chemical compounds are present in all foods. Many of these are necessary in the diet of animals, in amounts ranging from the great to the infinitely small, if proper growth and health is to be maintained. These necessary compounds can be conveniently classed into a number of groups as follows:—

The Fats and Carbohydrates.—(Fats, sugars, starches and "fibre") which are the main source of fuel or energy for body movements, growth and work.

The Proteins.—(Complex nitrogen containing compounds) which supply the structural materials for body growth, and repair.

The Minerals.—(Lime, phosphorus, magnesium, iron, copper, cobalt, etc.) necessary for the development of the bones and teeth and the blood and certain other essential body functions.

The Vitamins, or "Accessory Food Factors" necessary in minute amounts for the proper utilisation by the animal of the other food constituents and the maintenance of normal, healthy "metabolism" or general bodily processes.

More than a dozen of these vitamins have now been shown by scientists to have different functions in the animal organism. It should be clearly recognised that they are chemical compounds just like sugar or salt or starch, and are just as necessary in the food. The difference between the vitamins and the other "major" constituents of food is that the former function in much smaller quantities, and their mode of action in the body is not yet so clearly understood. The *principal* vitamins may be listed as follows:—

Vitamin A (including carotene) for growth, resistance to infection, health of the eyes, fertility, egg production and hatchability.

Vitamin B1 (thiamin) for growth, good appetite, healthy nervous system, and proper use of sugars and starches.

Vitamin B Complex (including riboflavin vit. B2.)—(there are a number under this heading)—for growth, healthy skin, eyes and mouth; for egg production and hatchability of eggs.

Vitamin C (ascorbic acid) for healthy teeth, gums and blood vessels.

Vitamin D, the sunshine vitamin, for growth and proper development of bones and teeth.

The Different Vitamin Requirements of Different Types of Animals.

At one time it was believed that the vitamins were only important in the nutrition of human beings and of small laboratory animals, such as rats and guinea pigs. It is true that in general they are more important for these species than for most farm animals kept under ordinary practical conditions. It is equally true, however, that under certain conditions vitamins may be of very great practical significance for farm animals. There are considerable differences between different species of animals in this respect. Thus pigs and poultry have high requirements for the members of the vitamin "B" complex, as well as for the other vitamins. Most of the members of the vitamin B complex are liberally supplied in the whole cereal grains, and particularly their by-products bran and pollard, which together generally make up the main part of pig and poultry rations.

In the case of sheep and cattle, on the other hand, the members of the vitamin B complex and vitamin C, are of no practical significance. This does not mean they do not need these important compounds. It means that under all practical feed conditions they are capable of manufacturing their own supplies by means of the vast numbers of bacteria and other micro-organisms in their capacious rumen or "paunch." This is a fortunate fact for farmers who have no worries with their sheep and cattle in this respect. The fat-soluble vitamins, i.e., vitamins A and D are, however, required by all species, and of the several members of this group vitamin A is likely to be easily the most important under ordinary farm conditions.

Riboflavin.—In contradistinction to the other members of the vitamin B complex, vitamin B2, or riboflavin is not very high in cereal feeds or in meatmeal. It is, however, present in considerable amounts in skim milk and butter milk, in greenstuffs and in liver meal. Riboflavin deficiency results in poor growth and even death in chicks and a typical "curled toe paralysis," which forces them to walk on their hocks with their toes curled inwards. In hens the deficiency reduces egg production, and results in a lower hatchability of the eggs, which are pro-

duced. It is therefore essential to see that growing chicks and laying hens are given regular and ample supplies of greenstuffs, or have small amounts of dried skim milk, or butter milk, or liver meal in their ration.

Vitamin D.—This vitamin is required for the proper absorption and utilisation of the minerals, lime and phosphorus in the production of sound teeth and bones. It is sometimes called the "sunshine vitamin" because it is formed in the skin of animals by the action of sunlight, and ultra violet rays. In those parts of the world where the winter is long and hard, and animals have to be housed for considerable periods special provision has to be made to supply extra amounts of this vitamin in the feed. Under our climatic conditions, however, there is no evidence as yet, that extra vitamin D is necessary at any time. A possible exception is the case of "battery-reared" chicks, in which small amounts of a suitable fish liver oil preparation rich in vitamin D might profitably be incorporated in the mash.

The Functions of Vitamin A or Carotene.

This vitamin, or carotene, which is readily converted into vitamin A in the animal body, is essential for growth of all animals. It is sometimes called the "anti-infective vitamin" because, under conditions of deficient intake, animals develop a great susceptibility to infections of the eye and of the respiratory, urinary and reproductive tracts. It appears that vitamin A is required to maintain normal healthy membranes in these parts of the body. Besides the infective condition of the eyes known as xerophthalmia, night-blindness, or inability to see well in dim light, also occurs in animals kept for some time on a diet even mildly deficient in vitamin A. In some species urinary "stones" or calculi develop as a result of deficiency and it may be that this is related to the occurrence of such calculi in sheep in some of the drier parts of the agricultural areas of W.A.

Vitamin A and Fertility in Animals.

The influence of vitamin A in maintaining healthy reproductive organs and membranes makes it of special importance in the fertility of farm animals. Research has shown that breeding animals need about three times as much vitamin A and five times as much carotene in their diet as non-breeding animals. The existence of reproductive troubles due to vitamin A deficiency under natural grazing conditions has been demonstrated in California towards the end of a long (6-9 months) dry-feed period. Calves were either born dead or very weak and often had severe diarrhoea. Ewes kept under vitamin A deficient conditions before and after mating conceived normally, but all the lambs were born dead or died within 24 hours. A diet of low vitamin A potency has been recently shown in N.S.W. markedly to reduce sperm production, and hence to lower fertility in the ram. Changing over to a diet of high vitamin A potency, i.e., containing plenty of green grass, or well cured lucerne or clover, hay or carrots or codliver oil, quickly resulted in a regeneration of sperm production.

Liver Reserves of Vitamin A.

All animal species and birds have the ability to store up, during periods of high intake, considerable reserves of vitamin A in their livers, and to a lesser extent in other parts of the body, which can be drawn upon during periods of low intake in the diet, or when specially large amounts are required for any purpose. This is of great practical importance, because it means that animals do not have to have foods rich in vitamin A all the time. For periods, varying in length with

the magnitude of the reserves previously built up, and with the extent of the deficiency at the time, they can get along, without any ill-effects, on a diet containing less than the minimum requirements of vitamin A or carotene.

In studies carried out in England it was shown that the ordinary cereal rations fed to pigs are very deficient in vitamin A, unless supplemented with some greenstuff or special fish oil preparation. If, however, the sow before and after farrowing, and the piglets from birth to weaning are provided with a ration amply supplemented with either the greenstuff or the fish oil, sufficient reserves of vitamin A are built up in the livers of the weaners to last them a further 4-5 months, i.e., up to six to seven months of age, without any ill effects even in the absence of any further supplements. After this time the reserves become dangerously low and loss of appetite followed by a paralysis of the hind limbs occurs.

In W.A. it was recently demonstrated that wethers and dry ewes, under the grazing conditions of the central districts of the agricultural areas, have very high reserves of vitamin A in their livers during the green feed period of the year (May to October). Thereafter depletion of these reserves takes place, but generally low values do not occur generally until late summer (March and April). A rapid rise in reserves then takes place with the advent of green feed in the next autumn. In ordinary summers it is very probable that the reserves built up during the winter and spring will be sufficient to carry wethers and dry ewes through without any evidence of deficiency, and the same remarks should apply to non-breeding and dry cattle grazing under the same conditions. With breeding stock, however, or with any grazing stock in exceptionally long, dry summers, as occurred in 1940, it is probable that vitamin A deficiency will affect health and reduce breeding efficiency. Sheep owners have long been familiar with the fact that satisfactory lambings generally follow a season of early opening rains, whereas late opening seasons, i.e., long, dry summers, are often followed by poorer lambings, with occasionally severe losses from abortions and lambs born dead. Undoubtedly, this is due largely to the general low level of nutrition of the ewes during such seasons, but specific vitamin A deficiency is probably a contributing factor. Suitable supplementary feeding of lambing ewes thus becomes essential during the late summer months if the chance of vitamin A deficiency is to be entirely eliminated.

Carotene Content of Pastures.

An examination of samples of representative pasture species from three different centres in the southern agricultural areas of W.A., disclosed the fact that their carotene content remained very high throughout the main growing period. As they matured and dried off, however, the carotene content fell rapidly at each centre, and by early November all the annual species studied were sufficiently low to make it necessary for grazing sheep and cattle to begin drawing upon their liver reserves of vitamin A. Throughout the rest of the summer it is reasonable to assume that the pastures were still more deficient. The legumes studied (subtennanean clover and burr trefoil) were higher than the grasses and other species and tended to retain their carotene longer into the important spring period. A pasture high in clovers would, therefore enable grazing animals to start off the summer with higher liver reserves and postpone slightly the time when they would have to start drawing upon them. In the same way a fairly productive later maturing grass such as Wimmera rye grass was found to maintain its carotene content slightly longer than a relatively poor early maturing grass, such as barley grass. A pasture containing a proportion of Wimmera rye grass to replace some of the poor grasses, would not only be improved in productivity and general composition, but would also be a better source of vitamin A. Pasture improvement

in general can therefore be expected to help the position of grazing stock in respect to vitamin supplies, but not to solve it. Where the summer is long, hot and dry, and no green picking is available the grazing will always be deficient in carotene. For non-breeding animals in summers of ordinary length this is probably not important, as pointed out earlier, because of the liver reserves, but for breeding animals it may be so, and knowledge of the value of the various supplements as a source of vitamin A becomes necessary.

Carotene Content of Fodders and Grains.

The chief summer supplements for sheep and cattle in this State are wheaten and oaten hay, clover and oaten silage, "meadow" or clover hay, and wheat, oats and barley grain.

The grains were all found to be consistently very low in carotene. Such materials can, therefore be regarded as poor supplements from the point of view of vitamin A, although they are very good sources of available energy, and also fair sources of protein, compared with the protein content of average dry summer grazing.

Of the other materials examined both oaten and clover silage were found to be easily the best sources of carotene and these fodders can be regarded as good vitamin A supplements to summer grazing. The hays were found to be exceedingly variable, but the "average" clover hay is usually appreciably higher in carotene than "average" oaten hay, and oaten hay higher than wheaten. Too much significance should not be attached to any difference between wheat and oaten hay in this connection, however, because of the great range of values found for each. Both the stage of maturity at hay-cutting time, the curing conditions in the field, and the length of storage have a profound influence on carotene content. In general it can be stated that any conditions which maintain a good green colour in hay, whether it be oaten or wheaten, will also result in a relatively good carotene content. "Prime" chaff of good colour was always found to be higher in carotene than chaff of a paler colour classed as medium or poor quality.

Vitamin A and Poultry Nutrition.

Reference has been made earlier to the fact that ordinary cereal plus meat-meat rations for poultry (and to a lesser extent for pigs) are likely to be deficient in riboflavin (vitamin B2), unless supplemented with green feed, skim milk or butter milk or liver meal. A deficiency of vitamin A is even more likely to occur with such rations unless plentiful amounts of green feed are supplied or small quantities of a reputable brand of cod liver oil, shark oil, or some similar preparation given at regular intervals.

On cereal rations without one of these supplements symptoms of deficiency will show up as soon as the body stores or reserves of vitamin A are used up. This may be within a month of dropping the green feed, or other source of vitamin A from the ration. Chicks and laying hens are particularly susceptible, but all birds will show signs of deficiency unless properly fed. The symptoms have been described in a previous journal article (Mahaffey, L. W., J. Department of Agric., W.A., March, 1941). Egg laying begins to drop off, the birds lose condition and their general resistance to many diseases is lowered. The hatchability of the eggs which are laid is also lowered. A condition develops known as "nutritional roup" characterised by whitish, cheesy deposits in the mouth and cavities of the head, watery "bung" eyes and difficult breathing.

All this can be prevented by feeding adequate green feed all the year round. About 7lb. per 100 hens per day can be regarded as near the minimum. Where

green feed is unavailable, or in short supply the vitamin A requirements can be equally well provided by incorporating, as suggested earlier, a good brand of fish liver oil ("poultry grade") into the mash at a level of about 2-4 tablespoons per 100 lb. of mash. It is essential to note that these oils lose their potency readily on exposure to light, or when mixed with cereal meals. They should be stored in a cool, dark place, and mixed in the mash as frequently as possible, or at not more than weekly intervals. Larger quantities of oil than those suggested will give no additional benefit, and will represent a waste of valuable oil and money.

GENERAL SUMMARY AND RECOMMENDATIONS.

A large number of accessory food factors or vitamins are now known to be necessary in small quantities for farm animals. Many of these are of little practical importance, particularly in the case of sheep and cattle.

Care is necessary to avoid trouble from deficiency of vitamin A in all species of animals under prolonged dry-feed conditions, and from an additional deficiency of vitamin B2 (riboflavin) in the case of poultry and pigs.

Vitamin A is required for growth, for resistance to various infections and for fertility in both male and female. Green feed is the best and cheapest source.

Conserved feeding stuffs can be ranged on an average in the following descending order of importance as a source of vitamin A:—Silage, clover or "meadow" hay, oaten hay, wheaten hay. Cereal grains are very poor sources.

The vitamin A potency of hays is highly dependent upon earliness of cutting and conditions of curing. Greenness of colour in hay is an excellent indication of relatively high vitamin A potency.

In the absence of green feed for more than very short periods growing chicks, laying hens, breeding sows and piglets up to weaning should receive regular small quantities of cod liver oil or other potent fish liver oil as a vitamin A supplement.

Cereal grain and meat meal rations are deficient in riboflavin for poultry and to a lesser extent pigs unless supplemented with either green feed, skim milk, buttermilk or liver meal.

An Electric Bird Scarer.

A NEW USE FOR THE ELECTRIC FENCE.

T. C. Miller, Horticultural Adviser.

A matter causing great concern to orchardists over the whole of the fruit growing areas of this State is the depredation of crops by birds. During recent years the number of these pests invading orchards has increased enormously, particularly in the apple growing districts where "white" tailed black cockatoos, king parrots and twenty-eight parrots have done most damage. The writer can recall one occasion while performing an orchard inspection at Manjimup when a flock of about twenty black cockatoos slipped quietly into one end of an orchard and when disturbed less than ten minutes later had destroyed what was conservatively estimated at forty cases of Democrat apples. Most growers can recall similar incidents, but it may be mentioned that a Donnybrook orchardist who had an official estimate of 1,000 cases of Cleos did not pick a case of this variety, due entirely to the ruining of the crop by this same destructive species.

Normally the method of combating these bird pests has been with patient watching, a good gun and plenty of ammunition, but wartime conditions and the subsequent shortage of labour and ammunition, have made it almost impossible to protect fruit crops satisfactorily in this way.

Many contraptions calculated to act as scares have been devised, a lot of them ingenious, and most of them weird, such as hanging mirrors which flash in the sunshine, and suspended bright kerosene tins which glare in the sun and clang together with the breeze, all of which have effect for a period until the birds become accustomed to them.

A patented American invention consisting of an acetylene generator, a pilot light and an explosion chamber fitted with a trap door, has possibilities. The acetylene gas is evolved by the action of water dripping on calcium carbide in the generator. It diffuses through the chamber, forming an explosive mixture with the air inside, and when this contacts the pilot light through a jet, a loud explosion occurs. The trap door acts as a safety valve, and the action is continuous and automatic. Up to the present the mechanical difficulties of this contrivance have not been solved in this State, but there is scope for a handy man to build one as the idea appears to be sound, and should be effective.

The possibility of adapting the electric fence to act as a bird scarer was first put to practical test by Mr. R. A. Andrews of Redmond, who reported very optimistically concerning the effectiveness of his trials. Consequently an experiment was carried out on an orchard at Karragullen to determine the efficacy of the electric fence as a scarer for birds, and to find the practical difficulties which would be experienced in erecting a suitable device. Mr. A. J. Davies, whose apple crop was severely damaged by birds the previous harvest, willingly co-operated in providing materials and labour for the construction of an experimental fence on his property, and Westralian Farmers, Ltd., kindly made available an electric fencer unit and battery. The Fruit Growing Industry Trust Fund Committee supplied insulators and various electrical fittings for the purpose of ascertaining which types were the most suitable in the construction.

The Stronghold electric fencer unit supplied is a very compact and efficient one, run by an ordinary 6-volt battery, and being capable of electrifying up to twenty miles of wire. All safety precautions are incorporated and it is particularly easy to set up and adjust.

CONSTRUCTION.

The general principle is to have the main wires from the battery and unit running along the side of the orchard, and wires to be electrified along each row of trees at right angles to the mains.

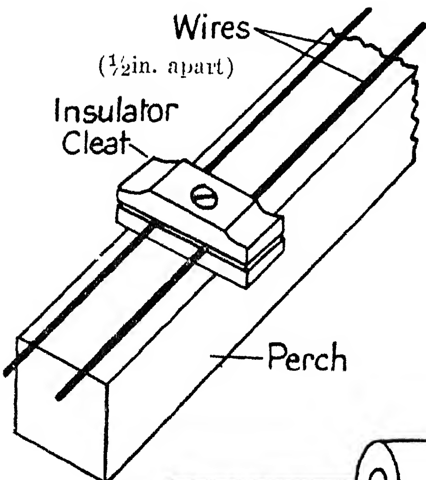
It is necessary to have a metallic earth, which is best supplied by a wire parallel and close to the live one, and so arranged that birds alighting on the perches provided will make contact with both wires.

Ordinary fencing wire can be used throughout the system and it is advisable to choose light gauge soft iron wire to give ease in manipulation.

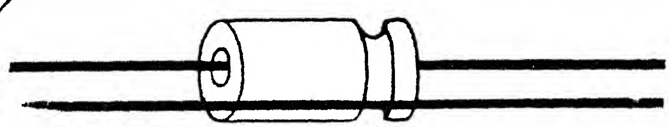
The two wires are run along the existing orchard fence posts using button insulators, or alternatively, posts of any convenient height may be used to carry them. In the case of the Stronghold fencer both main wires lead from the unit, but with some other types the positive terminal of the battery is connected with the fencer, and the negative to the earth wire. The live wire only, then runs from another terminal on the unit. No connection is made between the two mains, each

running to an insulator at the end of the orchard fence, and neither may be earthed.

The mains are attached securely to their respective terminals, and when the battery is connected with the fencer unit, the wires become charged. Due to the comparatively high potential of the current, there will be an appreciable loss in voltage if all joins right throughout are not well made, by either soldering or using strip bakelite connectors.



Method of attaching wires to perches.



Tube insulator to keep parallel wires apart.

ERECTION OF WIRES ALONG THE ROWS.

In the experiment performed at Karragullen, the two lengths of wire were run parallel, half an inch apart, over the top of a row of Yates trees—this row being selected as it was adjacent to uncleared forest land, and had suffered extensive destruction of its crop by parrots in the previous season. Where maypoles are erected at the centres of the trees, these would be ideal for supporting the wire, but in the experiment these not being available, a stout sapling was put alongside every second tree in the row. The saplings at the ends of the row were made firm with guy ropes, and the wires attached to them by means of egg insulators, as is usually done with an ordinary wireless aerial, and then strained as tightly as possible. The wires must not touch each other at either end or at any point along their length. If the fencing wire is not too heavy and can be strained well, there is little fear that they will touch, but it is safest to slip a number of tube insulators at intervals on one wire, as if they approach much under half an inch the current jumps across the gap and shorts the circuit.

On the top of each post or maypole is fixed a perch of 2in. x 1in. timber about five feet in length, running along the same direction as the parallel wires, and to these the wires are fixed by means of tubes or cleat insulators. The perches have the purpose of supporting the wires and providing a rest for birds. When the two wires are in position they are connected, one to each of the mains. Any number of pairs of parallel wires running along the rows can be connected to the mains at the end of the row, the limit being as mentioned above, twenty miles of wire.

The intention is that any bird settling on a perch will contact both wires and receive the severe shock delivered from the current produced by the fencer unit. The shock is not sufficient to kill ordinary birds, but has the same reaction as with stock, and any birds which make the contact will not approach that portion of the orchard again.

It is considered advisable to have the electrified wires running over the tops of the trees, but where the trees are vigorous and make several feet of growth during the season, it would be better to run the wires alongside the trees and level with the top layer of fruit.

While the system is in operation it is essential to make periodic inspections as there is a tendency for the current to jump across the shortest gap between the wires, and if at any place they come close together, due to a kink or a join in one of them, there is a big risk of shorting, and while contacting both wires under this condition still gives a considerable shock, the battery is being unnecessarily run down. It is interesting to note that during a period of three months the battery used—a small six volt—was recharged once only.

Section of fence showing: (1) Perch on top of post; (2) A perch suspended from wires in between trees.

RESULT.

It is a strange fact that, early in the season, considerable damage was done by smaller parrots to the immature fruit on the trees, but as the season progressed the number of birds troubling orchardists in general, decreased considerably, and little concern about this pest was experienced on this particular orchard where the experiment was conducted. This was very satisfactory to growers but not for the sake of the experiment, and consequently the usefulness of the construction as a bird scarer could not be definitely estimated. It is of interest to observe, however, that the wires and perches attracted quite a number of smaller birds which frequented the orchard, and they settled on it readily, but were not large enough to make the connection between the two electrified wires. From this it appears that the high perches and wires possess a certain attraction for birds, and it is considered that if a sufficient proportion of the destructive species receives a shock, it will cause them all to be afraid of the protected portions of the orchard.

CONCLUSION.

Providing the height of the trees does not require the wires to be fixed too high above the ground, and so long as satisfactory light gauge wire is available, the

labour and cost involved are not considerable, and once the posts are up and the perches made, the apparatus is permanent. Until, however, the idea can be given a fair trial in a season when the pest is bad, the electric fence as a bird scarer cannot readily be recommended, but from information gained and observations made last season, there is every reason to hope that the idea will give some measure of control to orchardists who are severely troubled by birds damaging their crops. It is hoped that more experimental fences can be erected during the coming season, and that more detailed observations will be able to be made.

Experiments with Safflower in Western Australia.

A. J. Millington.

In the long and romantic history of yellow dyeing the various plants used as sources of the pigment are known collectively, in common speech, as saffron flowers or safflower. The bindings of the 4,000 year old Egyptian mummies were dyed with flowers of the common or saffron crocus which was apparently the chief European source of this dyestuff. In India and the Far East, use was made of another or false safflower known to botanists as *Carthamus tinctorius*. The group to which this plant belongs contains also the saffron or star thistle (*C. Lanatus*) a serious noxious weed in Australia.

Typically *Carthamus tinctorius* has spiny leaves, but the variety *inermis* used in the recent experiments in Western Australia has spineless leaves except for those surrounding the flower head. The spiny type is usually preferred for oilseed production. For the purposes of this article, it is proposed to restrict the name Safflower to the spineless, *inermis* variety of *Carthamus tinctorius*.

Artificial dye manufactured chiefly from coal tar by-products have now replaced the natural one derived from safflower and it is mainly as a source of oilseed that safflower is cultivated, about 500,000 acres being sown in India each year.

The oil extracted from the seed has a much longer drying time than linseed oil, but it is superior for use in white paints and enamels where permanent whiteness is desired. It is also suitable for use as an edible salad oil.

Analyses of locally grown seed have given an oil yield of about 20 per cent. or only one half that of linseed. The cake remaining after the oil has been extracted from the seed is about the equivalent of bran as a stock food. It differs markedly from other seed meals in having a very high fibre content.

The earliest reported trials with safflower in Western Australia were made by G. F. Berthoud at Hamel State Farm in 1899. The seed was sown on fertile loam at the end of June and the plant matured in late February. This length of growing season is much greater than can usually be obtained in the wheat belt.

In 1941 a further supply of seed was imported into the State by the secretary of the trustees of the W.A. Wheat Pool, Mr. H. E. Braine, and portion made available to the Department of Agriculture for trials on the Research Stations in that year and again in 1942 The first planting was made late in June, 1941, at the Merredin, Avondale, and Wongan Hills Research Stations. The plots at Merredin in particular, showed considerable border effect indicating that a longer

growing season was desirable. This could be achieved only by sowing earlier in the season and consequently the 1942 plantings were made in May. The safflower made little growth during the winter and suffered considerable damage from red legged earthmite and lucerne flea, many plants being totally destroyed. The sparse foliage offered little competition to weeds and considerable volunteer growth occurred.

With warmer spring weather the plants grew rapidly and attained a height of 30-36 inches. The yields at Merredin and Wongan Hills in 1941 were 130 lb. and 687 lb. per acre respectively. In 1942 the yield at Merredin was 64 lb. per acre whilst those at Avondale and Wongan Hills were of the same order.

Flowering top of a typical safflower plant.

The seed is slightly smaller than that of most wheat varieties, but it is readily sown by the ordinary seed drill. Plots were harvested at the Avondale Research Station with a normal header but a heavier crop would necessitate the removal of alternate teeth from the comb. The fine hairs in the seed head caused the harvester driver considerable discomfort.

The potentialities of safflower as a weed is of importance since practically every other member of the genus is classified as such. As mentioned earlier it is closely related to the saffron or star thistle which has been a serious weed in all States of Australia. With these potentialities in mind every care to keep it quarantined was taken during trials on the Research Stations. Although stock readily grazed the young growth, the mature plants would be of little fodder value.

Breeding work is in progress to evolve satisfactory linseed varieties which will escape cutworm damage and resist rust. In view of the unreliability of the summer rainfall in the agricultural areas of Western Australia it is likely that when these are available, they will be a much better source of vegetable oil and pressed cake than safflower.

Grateful acknowledgment is made to the manager, Avondale Research Station, Mr. W. A. Human, and to Messrs. D. R. Bateman and E. Langfield of the Wongan Hills and Merredin Research Stations respectively, for their co-operation in this investigation.

The Red Spider.

(*Tetranychus urticae* Koch.*)

C. F. H. JENKINS, Government Entomologist.

The red spider is a very common pest of vegetables, garden plants and some types of fruit trees during the summer. It should not be confused, however, with the red-legged earth mite (*Halotydaeus destructor*), which is such a serious pest of seedlings, but during the winter season only.

The red spider was first described from Europe as long ago as 1761, and since then it has been recorded from most countries of the world.

Like the red-legged earth mite, the red spider is really a mite, not a true insect, but for all practical purposes it may be treated as such.

GENERAL DESCRIPTION.

The adult female is barely visible to the naked eye, being about one-fiftieth of an inch in length. The colour varies considerably, being often greenish brown or yellowish, but more generally rust or brick red. Darkish spots can usually be seen on the back with the aid of a strong magnifying lens. The male is smaller than the female and usually reddish in colour.

Being true mites, both sexes have eight legs, and not the customary six characteristic of insects.

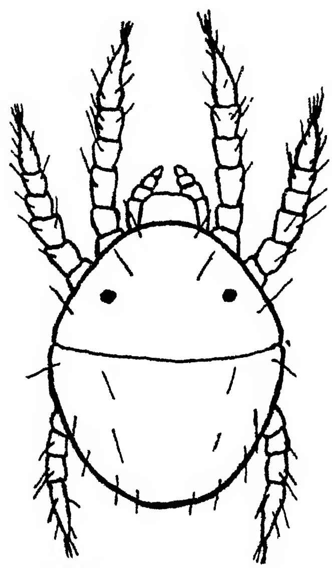
LIFE HISTORY AND HABITS.

The round, somewhat transparent eggs, which cannot be seen without the use of a hand lens, are laid on the under sides of the leaves of selected host plants.

* Usually called *T. telarius*.

Each female may lay from 70 to 100 eggs during her average life of two or three weeks, and usually lays from three to six daily. The eggs are laid irregularly on the leaf surface and under favourable conditions hatch in four or five days.

The young mites are almost transparent on first hatching, and have only six legs. They soon commence feeding and acquire a greenish tinge. Later they moult their first skin and become eight-legged like the adults. In warm weather the mites may reach maturity in a little over a week, so that from egg-laying to adult may occupy less than a fortnight. This rapid development explains how such swarms of red spiders can appear apparently from nowhere to plague our gardens during hot summer weather.



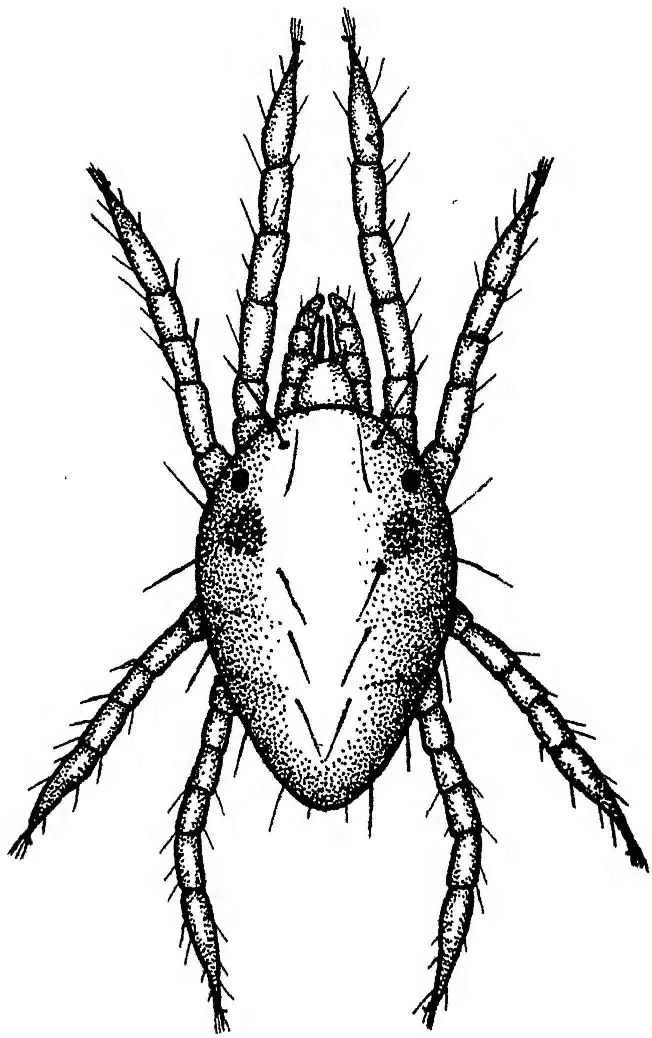
(Univ. Flor Exp. St.)
Young Red Spider (X 200).

The number of generations which can develop annually has never been worked out locally, but in parts of North America it is known that 24 broods may occur in a single year, and it is likely that a comparable number could develop in many parts of this State.

Although the normal life of the adult red spider, as already indicated, is only about a fortnight or three weeks, under cold conditions this period may be greatly lengthened. The females become inactive, shelter in secluded situations, and in this manner spend the winter. With the arrival of spring they again become active, and lay eggs which give rise to the first spring generation of the pest.

The mouth parts of the red spider are adapted for lacerating the plant tissue and sucking up the resultant oozing sap. The feeding injury causes pale spots to appear on the infested foliage, and soon leaves acquire a mottled and unhealthy appearance. A heavy infestation of the pest may cause the foliage to bleach altogether and finally to shrivel.

The web-spinning habit so characteristic of the red spider increases the disfigurement of the infested leaves. The threads of the webbing are too fine to see with the naked eye, but the under side of a badly attacked leaf often has the appearance of having been dusted with fine powder. This impression is conveyed by the numerous cast skins and excreta of the feeding "spiders" sticking to the leaf.

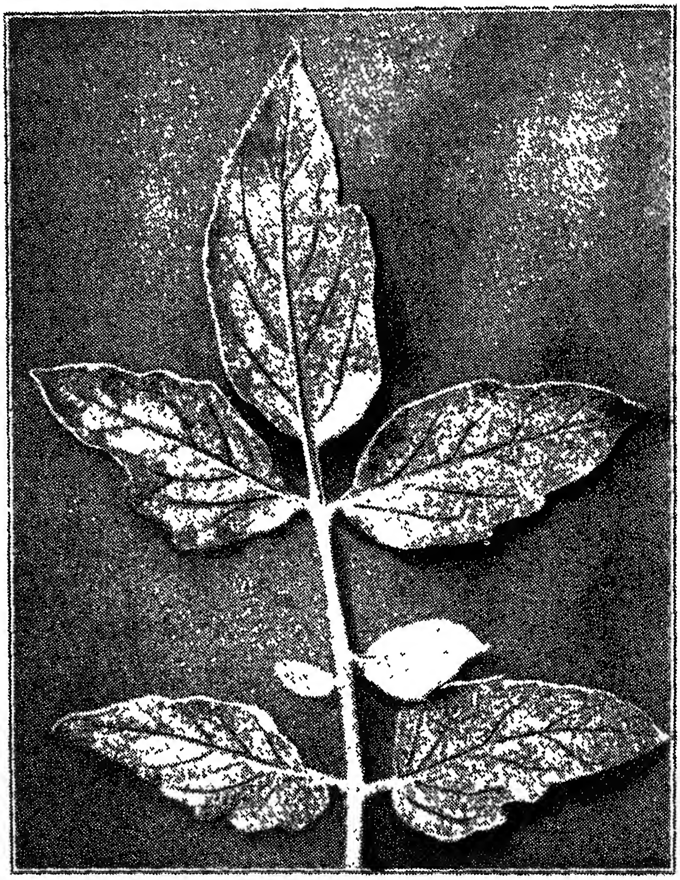


(Univ. Flor. Exp. St.)
Adult Male Red Spider (X 200).

Being quite devoid of wings or any other means of rapid progression, it may seem surprising that the red spider is so widespread. It has, of course, been carried from one country to another with introduced plants. Local dispersion would occur in the same way, but in addition it is known that the creature may be borne by the wind for considerable distance, and that it can also be swept from higher to lower ground by flood waters.

HOST PLANTS.

A complete list of host plants would be too long to include, but some examples are peas, beans, cucumbers, marrows, cotton, tomatoes, tobacco, violets, carnations, geraniums, and strawberries, as well as many shrubs and deciduous fruit trees.



Tomato shoot showing workings made by red spider.

CONTROL.

The effective control of the red spider entails prompt action and thorough treatments, especially to the under surface of the leaves as soon as the pest is detected.

Lime Sulphur.—Lime sulphur is probably the most useful spray and may be used at a strength appropriate to the plant to be treated. Under summer conditions lime sulphur is liable to burn foliage, and should generally not be used stronger than 1 to 60, and on delicate plants at about 1 to 100.

Sulphur Dust.—Dusting with flowers of sulphur is widely used against this pest with varying degrees of success. Experiments in America have shown that under dry arid conditions dusts are less effective than where the air is humid.

White Oil.—Like lime sulphur, proprietary white oil may be used at varying strengths according to the weather and the type of foliage to be treated. The strongest concentration for plants in summer, however, should not exceed 1 to 40, and may require to be as low as 1 to 100.

Black Leaf 40, so useful as a contact spray against most insects, has proved disappointing against red spider in American experiments, and home-made sprays such as kerosene emulsion have given far better results.

Kerosene Emulsion.—Kerosene emulsion may be made as follows:—Dissolve ½ lb. of soap in one gallon of hot water. Add slowly two gallons of kerosene, stirring violently the while. This makes a stock solution which may be kept. When required for use the stock solution may be broken down at the rate of one part to 8-14 parts of warm water. The weaker strengths should be used on delicate foliage or during very hot weather.

Flour Paste.—Another simple preparation which has been successfully used is flour paste. The stock material is prepared by making a boiled paste with 1 lb. of flour and a gallon of water. For use against the pest it is broken down at the rate of one part of stock to nine parts of water, and applied with a strong spray pump so as to thoroughly coat the foliage above and below.

Cultural Methods.

It has been frequently shown that the red spider thrives best under hot, dry conditions. Where plants can be kept well watered, especially with overhead sprinklers, the result is a definite drop in the "spider" population, and this means of control is adopted by many gardeners.

As the red spider attacks many weeds as well as cultivated plants, the necessity for clean cultivation will be self evident.

Mycotic Dermatitis ("Lumpy Wool") and Fleece Rot of Sheep.

C. R. TOOP, Senior Veterinary Surgeon.

During recent months a number of samples of matted wool from the higher rainfall areas of the southern districts have been forwarded for examination. An investigation has revealed the presence of two similar, though not identical conditions, viz.: mycotic dermatitis or "lumpy wool" and fleece rot. The existence of both conditions has been recognised in this State for a number of years, but since the cases encountered have been isolated or sporadic in nature their occurrence has hitherto been regarded as a matter of minor importance.

During the present season, however, a considerable number of flocks were reported to have become affected; a high percentage of the younger sheep showing evidence of matted and sometimes discolored wool at shearing time. In such flocks considerable losses have been sustained both as the result of damage to the fleece, and the difficulty of shearing badly affected animals from which much of the wool cannot be removed. Moreover, affected sheep are rendered highly susceptible to blowfly attack. Body strikes may occur, which unless promptly treated are likely to become extremely severe.

Both mycotic dermatitis and fleece rot are dependant for their development upon the presence of moisture in the fleece. They are consequently only likely to occur in seasons of high rainfall during which the fleece is frequently soaked in water. Abnormal summer and autumn rains accompanied by humidity, warm temperatures and a luxuriant growth of pasture may be regarded as having been responsible for the widespread occurrence of both conditions during the present season.

MYCOTIC DERMATITIS ("LUMPY WOOL").

This condition is caused by a fungus known as *Actinomyces dermatonomus*, which is widely distributed in the soil and elsewhere. It is frequently present in the wool of sheep. During seasons of high rainfall when conditions of moisture are favourable to the organism it grows in the wool, and invades the underlying skin, setting up a condition of inflammation or dermatitis accompanied by exudation, and the formation of crusts or scabs, which bind the wool fibres firmly together. As the condition develops areas of hard matted wool make their appearance in the fleece. The affected areas are roughly circular in outline, measuring from a quarter of an inch to an inch or more in diameter, and extending from an inch to about three inches along the wool fibres. Upon examining an affected sheep, hard horn-like processes will be detected projecting upwards into the fleece. In full woolled sheep the external half of the fleece usually shows no alteration; externally the animal is normal in appearance, and the condition may only be discovered during shearing. This condition is usually confined to the back and sides of the animal, though isolated cases have been observed where other portions of the body including the head and limbs have been affected. In advanced cases isolated areas of affected wool become confluent and in consequence large areas of the skin become covered with hard masses of matted wool. The matted wool is firmly adherent to the underlying skin, leaving a raw bleeding surface if forcibly detached. With the passage of time the crusts tend to separate from the skin, and are pushed outwards by a new growth of wool from beneath. Shedding of the affected wool may subsequently occur.

Mycotic dermatitis is largely a disease of young sheep, older animals being much more resistant. The disease does not usually recur. An animal affected during one season is generally found to be unaffected at the following shearing. The disease has been observed chiefly amongst merinos; crossbreds are, however, susceptible and occasional cases have been reported amongst the British breeds.

Usually the general health and condition of affected sheep is not seriously impaired. Considerable losses are, however, sustained from the reduction in value of the damaged fleece. Moreover, the presence of the hard horn-like lumps in the wool renders shearing difficult, and frequently impossible.

Mycotic dermatitis.—Note matting together of wool fibres with crusts of hardened exudate.

Prevention.

The fungus is destroyed by copper sulphate in a strength of one in five hundred. Dipping in such a solution, which may be prepared by the addition of one pound of copper culphate (bluestone) to every fifty gallons of water, may therefore be found effective as a preventive measure. Dipping should be carried out during late autumn and the treatment may be repeated after an interval of ten days as an additional precaution. It should at the same time be recognised that the disease is unlikely to reappear except in excessively wet years. Bluestone in the strength mentioned does not stain the wool.

FLEECE ROT.

Like mycotic dermatitis, fleece rot occurs under conditions of excessive rainfall. It is caused by the multiplication of bacteria on the skin. The bacteria responsible are commonly present in the soil, especially in the vicinity of sheep yards, and are carried into the wool by dust. When the wool remains wet for prolonged periods, and particularly if the atmospheric conditions are warm and humid, these organisms multiply rapidly on the surface of the skin, setting up an inflammatory process with the formation of an exudate, which mats the wool fibres together. The wool covering the withers, back and sides is most commonly affected. The examination of an affected sheep will reveal the presence of a greyish yellow band of matted wool, one eighth to half an inch in width at a level in the fleece corresponding with the period when the inflammatory process occurred. Should the condition recur with the onset of further rains a second band may be observed, but at a lower level in the fleece, closer to the skin. There is an entire absence of the lumpiness so characteristic of mycotic dermatitis.

Fleece rot.—Note band of matted discoloured wool. The later growth of wool closer to the skin is unaffected.—After Seddon.

Some of the organisms responsible for the development of fleece rot, during their growth produce pigments which discolour the wool. Colours including green, yellow, blue, red, brown, violet and black have been observed. A green discoloration of the wool caused by an organism known as *Pseudomonas aeruginosa* is commonly observed in this State. The discoloration is usually confined to the matted bands of wool, but may be diffused throughout the greater portion of the staple, extending almost to the tip.

Young sheep 6-12 months old are more severely affected, probably on account of the openness of the fleece, which allows the penetration of moisture. Sheep of all breeds are susceptible, but the condition has been most frequently observed in merinos.

Since the bacteria responsible are widely distributed in the soil, and are therefore probably always present in the wool, fleece rot is not amenable to control by dipping.

Belschner, who has investigated this condition in New South Wales, particularly in reference to its association with blowfly strike, has observed that some sheep are much more susceptible to fleece rot than others. He considers that body conformation and fleece character have an important bearing upon its development. Sheep showing faulty conformation, including a "pinch" or "grip" behind the withers, high shoulder blades and broad withers with a depression between the shoulder blades, all of which conditions favour the entrance and retention of moisture, are predisposed to fleece rot. Furthermore, sheep carrying wool which is harsh to handle, shows a good deal of yellow coloration of yolk and lacks character are considered to be much more susceptible than sheep in which the wool is bright in colour, soft to handle and exhibits good character.

Belschner considers that the incidence of fleece rot could be considerably reduced by the systematic culling of sheep showing these undesirable characteristics.

Blowfly Strike.

Sheep affected by both fleece rot and mycotic dermatitis are rendered susceptible to attack by blowflies. An odour attractive to the fly is produced and the moisture present is favourable to the development of the maggots. Extensive strikes involving the withers, back and sides may result and unless promptly treated these may cause the death of the animal. Treatment involves the removal of a considerable amount of the most valuable part of the fleece.

The Preservation of Fruits in the Home.

RAY C. OWEN and W. J. BETTENAY.

The importance of fruit as part of the human diet has long been recognised as a factor in maintaining bodily health and the slogan "Eat More Fruit" could probably be practised to advantage by us all. Most fruits with which we are familiar contain in addition to carbo-hydrates and proteins, certain amounts of mineral salts, besides appreciable quantities of vitamins. The organic acids, too, together with the roughage or fibrous part of the fruit, do much to keep the human system functioning correctly. In Western Australia many fruits can be grown to perfection, and while in season, little trouble is experienced in obtaining supplies of any particular variety. Unfortunately the harvesting period of certain varieties is of very short duration, and to enable supplies to be carried throughout the year, it is necessary to resort to some method of preservation.

To preserve fruit means to keep it in a sound condition so that it will be fit for human consumption for a longer period than its normal season. It is not the purpose of this article to describe all methods of food preservation, but two

popular methods by which fruit can be preserved in the home will be dealt with. In view of the general food shortage, and the fact that many of the products from our commercial food factories are required for the fighting services, every effort should be made to preserve at least part of the coming crop for use when fresh fruit is scarce or unobtainable.

Fermentation and putrefaction are two changes by which perishable foodstuffs may be rendered unfit for human consumption and they are brought about by tiny living organisms such as bacteria, moulds, etc. Fresh fruits are readily acted upon by these micro organisms, once they have gained access through the skin, and successful preservation processes usually involve either—

(1) The destruction of these organisms (generally by heat) then hermetically sealing the product to prevent reinfection, e.g., canned or bottled fruit and fruit juices.

(2) Changing the nature of the product so that the growth of spoilage organisms is inhibited as in dried fruit.

Both these methods may result in some loss of vitamin content, but if the operations are carried out with due care, the loss can be kept to a minimum and the colour, flavour, and texture of the final product will not be unduly impaired. Practically all types and varieties of fruit can be bottled or dried as desired but some lend themselves better to bottling, whilst others yield a much superior dried product. Vine fruits are almost exclusively preserved by drying.

CANNING OR BOTTLING OF FRUIT.

Canning has been defined as the preservation of foods in hermetically sealed containers by sterilisation by heat. In its broader sense it includes preservation by sterilising in glass containers as well as in tin cans. Glass jars are used almost universally as containers for home "bottled" fruits, and because glass is easily cleaned and is unaffected by fruit acids, these jars are ideal for the purpose. Care must be used in the handling of glass containers, and they should never be subjected to sudden changes of temperature. Jars for bottling fruit should have a wide mouth to allow of easy filling, and should be fitted with screw tops or covers which can be held in place by metal clips. They should also be equipped with suitable rubber rings to ensure a perfect seal between the cover and the jar. This is most important, as an improperly sealed cover would allow the entry of spoilage organisms and the product would soon be unfit to eat.

The equipment necessary for the bottling of fruit in the home is very simple, and apart from the containers to hold the finished article, consists essentially of a vat or sterilising vessel in which the jars are placed whilst being sterilised. There are on the market well-known makes of sterilising outfits, fitted with suitable stands and equipped with thermometers, but in an emergency the washing copper or a kerosene tin may be used for the purpose. A rack or platform should be placed in the bottom of the steriliser to keep the jars from coming in direct contact with the bottom. Sufficient water is added so that its surface is just below the level of the rack, and a reasonably tight fitting lid or cover is fitted to retain most of the steam when processing takes place. In between batches the level of the water must be checked to obviate the danger of boiling dry. A thermometer is useful but not really essential when preserving tree fruits, as all of these varieties can be sterilised at temperatures below the boiling point of water, and temperatures up to 212° F. are not really harmful. The time necessary to give adequate sterilisation varies with the type of fruit being processed, but the simplest method is to process until the product is properly cooked, and this can be determined by

testing the firmness with a sterilised darning needle or knitting needle. Probe into the centre of the jar and if the product is sufficiently cooked, the texture will be soft but not mushy. The times given for each variety are only approximate and should be taken from the time the water in the steriliser reaches boiling point. Large jars will naturally need a longer cooking process than smaller containers as the heat penetration is more rapid in the latter. Overcooking spoils the appearance of the fruit and causes it to rise in the jar.

Fruit for bottling should be of the best quality, i.e., free from blemishes, of a good colour, full flavour and firm texture. Soft or over-ripe fruit will not stand up to the cooking process, and the product is likely to be mushy. In general, poor fruit is not worth the trouble of bottling and would be better made into jam. Fruit may be bottled with or without the addition of sugar syrup but the majority of fruits retain a better flavour when bottled in syrup than when plain water is used. The strength and consistency of the syrup may be varied according to taste or in keeping with sugar supplies. A good syrup suitable for most fruits can be made by using 4 to 6 ounces of white sugar to a pint of water. If too much sugar is used the syrup will be so dense that the fruit will have a tendency to rise or float to the surface. In making the syrup the required amount of water is brought to the boil in a suitable vessel—one fitted with a spout will facilitate pouring the contents into the jars—the sugar is added, and after boiling for 10 minutes the syrup is ready for use. Prolonged boiling will evaporate a portion of the water and thus increase the strength of the syrup.

General Preparation of Fruit.

As mentioned previously the fruit should be selected for quality and ripeness, and any which is inferior or over-ripe should be discarded. A thorough wash in cold water is advisable to clean the fruit from dust and grit. Different kinds of fruit need different preparation treatment as detailed hereunder.

Peaches.—Most varieties are suitable, but those with firm flesh are preferable as they do not break up during processing. Some people consider that the yellow-fleshed varieties look more attractive than the other types. Peaches should be peeled, and may be preserved whole or halved, or sliced as desired. Peeling can be done by hand with a knife, or by dipping the fruit in a boiling caustic soda solution for half a minute or so. The latter method is only suitable for solid fleshed canning varieties of peaches. The dip is made by using 4 ounces of caustic soda to a gallon of water, and after dipping, the peaches are thoroughly washed in several changes of fresh cold water to remove the particles of skin. When peeling by hand it is sometimes noticed that certain varieties tend to discolour if exposed to the air. If these are cut and placed in a weak salt solution and kept there till ready for bottling, no discolouration will occur. When prepared, pack the fruit in the bottles as firmly as possible without crushing, and cover with cold syrup, place in the steriliser, and process for 30 to 40 minutes, after which time remove from the steriliser, top up with boiling syrup and seal immediately.

Plums.—Practically all varieties of English plums and most of the firm fleshed Japanese plums are suitable for bottling. They are often preserved whole without removing the stones, but if desired they may be halved and stoned. Pack tightly into the jars, but only partially fill with syrup. Process for 10 to 15 minutes at boiling point or from 30 minutes at 170° F. The lower temperature is said to prevent the skins from cracking. Fill with boiling syrup before closing the jar.

Apricots.—Mid-season and late varieties are superior to the early types and may be bottled as whole fruit or as halves, but the skin is not removed. Here

again it is advisable to only partly fill the jar with syrup before processing, but be certain to top up with boiling syrup before sealing. Process for 20 to 25 minutes.

Nectarines.—Prepare and treat as directed for apricots.

Pears.—Bartletts and Packham's Triumph appear to be the best varieties for bottling, as they are well flavoured, and retain their white colour. The fruit should be used before it becomes ripe enough to eat. The stems are removed and the pears peeled and halved or cut into quarters if too large. Trim out the core and pack into the jars and cover with cold syrup. Sterilise for 25 to 30 minutes and finish off as described for other fruits.

Quinces.—These should be peeled and sliced, at the same time removing the core. As there is a tendency for the pieces to discolour, it is desirable to keep them in salted water till ready to fill the jars. Rinse in cold water and after packing into the jars, fill with cold syrup and sterilise for 30 minutes or so. Long cooking gives a red to pink colour, whilst a short cook gives more of a golden tint to the fruit. Top up with boiling syrup, and seal the jars as promptly as possible.

Tomatoes.—These may be bottled whole or in pieces, peeled or with the skins left on. Wash in cold water to remove any dirt, immerse in boiling water for 1½ to 2 minutes to facilitate peeling, and core with a sharp knife. Place a teaspoonful of salt in the bottom of each jar, pack the tomatoes in tightly, and fill with water. Sterilise for 25 to 35 minutes, top up with boiling water and seal.

Other varieties of fruit can be prepared, using methods similar to those described above.

Sterilising.

After the fruit has been prepared and packed firmly into the jars with or without syrup, the lids or covers are placed loosely in position without the sealing rings. The containers are then packed into the steriliser, which should be fitted with a rack or platform to keep the bottles from contacting the bottom of the steriliser. The vessel is then partly filled with water and placed over a fire or other heating appliance, until the water has boiled sufficiently long to sterilise the fruit. When sterilising is complete, the bottles are taken out one at a time, the covers removed, and after fitting the rubber rings, each is completely filled to overflowing with boiling syrup. The cover is then screwed or clamped firmly into position. This should be done in a warm room free from draughts. As the bottles cool, a vacuum is formed in the headspace above the contents, and this vacuum indicates a perfect seal between the bottle and the cover.

The vacuum may be tested when the jar has cooled by loosening or removing the clips, and then lifting the jar by the cover. If the seal is imperfect there will be no vacuum present and the cover will lift readily without raising the bottle. Screw-top jars may be inverted and stood on their covers whilst cooling and any imperfection in the seal will be shown by air bubbles originating at the seal and rising to the surface of the syrup. Should the bottled fruit begin to bubble or ferment within a few days of bottling it means that there has been a bad seal or the fruit has not been sufficiently sterilised. The lid should be removed and the bottle again sterilised for 10 to 12 minutes, overflowed with boiling syrup and resealed, preferably with a new rubber ring.

When properly sealed and sterilised, bottled fruit will keep in good condition for years, but the bottles should be stored in a cool dry place, preferably in the dark, as exposure to direct light is likely to bleach the colour and spoil the appearance of the contents.

There is also another method for the home bottling of fruit which is quite successful, and if anything, even more simple than the one described. This is known as the "Open pan system," or the "Hot filling" method, but is not altogether suitable for the preserving of the softer types of fruit, especially raspberries and strawberries. The fruit is prepared in the usual way and then placed in a suitable cooking vessel. An enamel-lined preserving pan is ideal for the purpose, but a large aluminium pot is quite suitable. Add sufficient sugar syrup to cover the fruit, and place over the stove or open fire and gently boil till the fruit is properly cooked. While the fruit is cooking the empty bottles are preheated and sterilised by being boiled in water and then whilst still hot, are filled with the cooked fruit. Sealing rings are fitted, and then the jars overflowed with boiling syrup and the covers are clamped on as previously described.

Special Note.—It is worth noting that owing to the shortage of rubber, manufacturers have found it necessary to make the sealing rings from reclaimed rubber. These are inclined to have a strong rubbery smell which has at times tainted the preserved fruit. To eliminate this objectionable feature, it has been advised that new black rubber rings should be thoroughly washed in hot water and scrubbed in the palm of the hand as though washing clothes, and then rinsed in clean cold water. They should be stretched to their full extent half a dozen times before fitting on the jars.

It has also been advocated that in addition to this treatment the rings should be soaked in a basin containing a little of the syrup used in preserving the fruit. This lot of syrup would naturally be discarded afterwards. Should the fruit have a slight rubbery taste when the jars are opened, empty the contents into a dish and allow to stand for 10 minutes before using, or if it appears very pronounced, place in a saucepan and bring to the boil. Empty into a dish and allow to cool, by which time the rubbery taste should have disappeared.

HOME BOTTLING OF VEGETABLES.

Vegetables in general contain much less acid than fruits, and also because there is a likelihood of contamination by certain soil bacteria, they require a much longer cooking process to ensure proper sterilisation.

Commercial canning processes involve pressure cooking at temperatures of 240° to 250° F. for periods of 30 to 40 minutes (according to the variety being treated), so it will be realised that ordinary household methods of food bottling cannot be regarded as adequate for the preservation of vegetables. For this reason there is a certain element of risk associated with the eating of home bottled vegetables, therefore this method of preservation cannot be recommended.

FRUIT DRYING.

As mentioned previously, most kinds of fruit can be successfully preserved by drying or dehydration. The principle underlying the process is to render the product so dry that any spoilage organisms are unable to develop. With dried fruits the sugars and organic acids become so concentrated that they, too, materially assist in keeping the product wholesome. Vegetables, because they are very low in sugars, must be dried to a much lower moisture content in order to keep them satisfactorily, and a moisture content of 4 to 8 per cent. is necessary with dried vegetables, whereas dried fruits keep well, even when containing up to 20 per cent. of moisture.

The term "dried" as regards fruit is usually applied to those fruits which have had the moisture removed by natural heat, that is, dried in the normal atmosphere by the heat of the sun. "Dehydration" on the other hand, generally indicates the process where the moisture is removed by artificial means, that is, dried in a chamber which is subjected to forced draught and artificially applied heat. The greater part of Australia's dried fruit crop, consisting of dried peaches, apricots, prunes, pears, currants, lexias and sultanas, is sun dried, and artificially heated dehydrators are only occasionally used to finish off the drying process when the weather is unsuitable. Dried or dehydrated apples, on the other hand, are mainly dried in tunnel or kiln type dehydrators, using artificial heat. The chief point in favour of sun drying is that it is much cheaper than artificial dehydration, because no expensive drying plant is involved. There is no doubt, however, that with artificial dehydration, where both the humidity and the temperature can be controlled, a superior product can be obtained. Research work has indicated that tree fruits such as peaches, apricots and pears, if blanched in steam or water for periods up to five minutes prior to sulphuring, and then dehydrated in a tunnel dehydrator, not only have a better colour, flavour and texture than the sun dried article, but vitamin retention is higher and the keeping qualities are very much improved.

This blanching treatment is advantageous in that it—

1. Enables the fruit to absorb sulphur fumes much more readily than with unblanched fruit, and so reduces the time necessary for sulphuring.
2. Accelerates the drying rate by as much as 30 per cent.
3. Reduces the tendency of the fruit sticking to the trays.
4. By inactivating the enzymes responsible, much darkening of the fruit during storage is prevented.

It is possible that blanching treatment and artificial dehydration will be adopted as a general practice in treating Australia's dried tree-fruit crop after the war, but much will depend on whether the increased costs of these methods will be repaid by the enhanced prices that the superior product should command on the world's markets.

Although the underlying principles are the same, each type of fruit has its individual method of treatment prior to and during drying or dehydration, and the methods described here are applicable to the drying of fruits in the home. In commercial practice vine fruits (with the exception of raisins which are dried on trays), are dried on permanent racks having timber frames and with tiers of wire netting racks arranged one above the other, and with a suitable roof to afford protection from the weather. Hessian sides or curtains are provided to shield the fruit from the direct rays of the sun, which have a tendency to bleach the fruit. These curtains provide useful shelter from rain which may be blown on the fruit should a storm occur during the drying period. The racks must not be kept too closely covered as moulding is likely to occur if the humidity is very high.

When placing the fresh fruit on the racks, the top tiers are filled with fruit and a sheet of hessian is placed on the bottom tier to catch the loose berries which fall through from the tiers above. This hessian also collects the dried berries as they are shaken down prior to being placed in the sweat boxes. Tree fruits are generally dried on wooden trays which can be spread out in the sun for drying or stacked one above the other and covered, if necessary, to protect from rain, heavy dews or dust storms.

Currants should be left on the vine until thoroughly ripe, and of an even dark colour. After picking they are spread one bunch deep on wire netting trays or racks. The trays should be stacked one above the other and the top one covered to protect the fruit from the direct rays of the sun. In good weather the currants will take from two to three weeks to dry sufficiently to shake off the bunches. It will be found, however, that the individual berries are not uniformly dry and it is necessary to place them in sweat boxes (petrol or kerosene cases are often used) for the moisture to become uniform throughout. This will take several days, by which time the currants will be ready for cleaning, to remove the remaining stalks, cap stems, dust and other foreign matter. In large commercial packing sheds this cleaning is done by special machinery, but in the home it must be done by hand methods.

Sultanas must be fully ripe before picking if a good finished product is desired. If allowed to dry without any preliminary treatment, sultanas would have a dark bluish appearance, due to the natural bloom on the fruit, and would look very unattractive. To remove this bloom or waxy covering, the fresh fruit is immersed in a caustic dip for a few seconds. Commercially the "cold" and the "mixed" dips (using caustic, potash, olive oil and a suitable wetting agent) are favoured. With these the finished product is a much lighter and brighter colour. However, the "hot" dip is still used by some, as the berries dry much faster, but the resulting dried fruit is definitely of the brown type. For home drying purposes the hot dip is the simplest and consists of placing the fruit in dipping baskets and immersing for one to two seconds in a boiling caustic solution made by using approximately 1 lb. of caustic soda to 30 gallons of water.

A serviceable dipping basket can be made by freely perforating a kerosene tin bucket with a suitable punch. The holes should be punched from the inside so that any sharp edges will be on the outside and will not come into contact with the fruit. Any large vessel in which water can be kept boiling will serve as a dipping tank. It should be equipped with a draining board so that excess liquid from the dipped fruit can drain back into the tank. Freshly dipped fruit should show minute cracks barely visible to the naked eye, in the skin. Allow the dipped fruit to drain for half a minute and then spread on racks or wire trays as recommended for currants. When the berries are sufficiently dry, so that no juice exudes when pressed between the finger and the thumb, they can be exposed to the sun to complete the drying process. After this the fruit is placed in sweat boxes and finally cleaned to remove stems and any other foreign matter.

Lexias and Raisins.—When Muscat Gordo Blanco grapes are dipped and dried, they become lexias, but when dried without dipping (usually on trays in the sun or in a dehydrator) they become table raisins or muscatel clusters. Lexias should have a rich golden brown colour, and should be large and well bodied. Table raisins have a dark bluish brown colour, and should retain their natural bloom. As with currants and sultanas the fresh fruit must be allowed to ripen thoroughly on the vine before picking. The most satisfactory dip for lexias is the boiling caustic dip, using approximately 1½ lbs. caustic soda to 50 gallons of water. Test a sample of fruit by dipping for two or three seconds in the boiling solution, and if necessary add more soda until the skin is cracked satisfactorily, but if the skins are tender and crack too much, dilute the dip by adding more water. The dipping solution should be kept boiling whilst dipping is being carried out. After draining the bunches are spread on racks to dry and when sufficiently dry are rubbed off the bunches, exposed to the sun, if necessary, then allowed to sweat in boxes before cleaning.

Drying of Prunes.—Suitable varieties are Prune d'Agen, Robe de Sargent, Splendour, Fellenberg, Imperial and sugar prunes. The fruit must be perfectly tree ripened, in fact it is preferable to allow the fruit to fall to the ground and be picked up rather than to be picked too soon. Only sound fruit should be used. Prunes are dried whole usually after dipping in boiling caustic solution. The strength of the dip may be varied with the condition of the fruit, but after a dip of five seconds, very small cracks should be visible in the skin of the prunes. A strength of 1 lb. caustic soda to 40 gallons of water is usually sufficient for Prune d'Agen. The solution must be kept boiling throughout dipping operations. Where large quantities of fruit are to be dipped, the dipping solution should be changed frequently as it becomes loaded with syrup and this covers the fruit, thus preventing the prunes from drying quickly. The fruit should be allowed to dry for several minutes before being spread on wooden trays. In hot weather the freshly dipped prunes should not be exposed to the sun, but should be kept shaded for several hours, as there is a tendency for the skins to burst. As drying proceeds the prunes should be turned at intervals to allow of more even drying. Any broken or faulty fruit noticed are better discarded at this stage. Usually the small fruits will have dried sufficiently before the larger ones, and it is a good practice to remove these from the trays before they become too hard. They should feel tough but should not exude any moisture when squeezed between the thumb and finger. The flesh should be meaty, but not hard and dry. After removal from the trays prunes are placed in large sweat boxes for two to three weeks, during which time they can be turned and mixed by pouring from one box to another. After thorough sweating, dip the fruit in clean hot water and dry again in the sun for a few hours before being packed for storage. A better appearance is given to the fruit if a small quantity of glycerine (1 lb. to 20 gallons) is added to the hot water in the final dip.

Figs.—Light coloured figs are best for drying, as the product has a better appearance than that from the dark varieties. They must be thoroughly ripe and care should be exercised in picking to see that the stems are retained on the fruit. After gathering the figs are dipped in a solution of boiling brine for three seconds. This brine is prepared by dissolving 3 ozs. of common salt in each gallon of water. This dip improves the texture of the skin and facilitates the evaporation of the water from the figs. After dipping the fruit is spread on wooden trays and placed in the sun to dry. The figs should be turned after a few days to expose the underside and so prevent moulding. In good weather the drying will be complete in seven to 10 days. As with other fruits the trays should be stacked and covered in the event of rain or heavy dews intervening during the drying period. When removed from the trays the fruit should still be pliable, but not sufficiently moist to exude juice when pressed between the thumb and finger. Sweating in boxes for a fortnight will ensure that the moisture has become uniform. Before packing the fruit is again dipped in the brine solution and quickly dried in the sun. This last dip removes dirt and grit and makes the skin smooth and pliable.

Peaches.—For home drying purposes free-stone yellow fleshed varieties such as Elberta, Muir and Blackburn are most suitable, but clingstone canning types such as Pullar's Cling and Golden Queen, etc., may be used. The fruit should be picked when fully mature and kept till fully ripe, but still firm, and then halved and the stones removed. This is a simple operation with free-stone varieties, but with clingstones a special knife or sharp edged spoon is necessary to remove the stone. Peaches may be dried without peeling, but if preferred may be peeled either by hand with a knife or by means of a caustic dip, followed by rinsing several times in cold water. In order to prevent the peaches from darkening, both during

the drying period and during storage, they are sulphured immediately after being halved. The prepared fruit is placed on wooden trays with the cut side uppermost and the trays are then stacked in an airtight chamber and subjected to sulphur fumes, produced by burning sulphur with a minimum supply of air. If a suitable sulphuring chamber is not available, the trays may be stacked in the open and covered with a heavy tarpaulin which is sealed at the bottom by covering the lower edges with damp earth. Space should be left at the side of the stack for the container in which the sulphur is to be burned. Usually 1 lb. of sulphur for every hundred cubic foot of space contained in the chamber or under the tarpaulin is required. This amount is placed in a fire pot in the chamber and when ready for sealing the sulphur is ignited with a few burning coals. The fruit should be left in the sulphur chamber for 10 to 12 hours, after which the trays are spread out in the sun till the peaches are dried. In favourable weather drying should be complete in four to six days, but if wet weather intervenes, this period may be greatly extended, and if unduly prolonged, it is necessary to resulphur the partially dried fruit. When completely dried the peaches are taken off the trays and stored to prevent infestation by insects, such as weevils and dried fruit moths.

Apricots.—Suitable varieties are Royal, Oullins, Blenheim, Travatt and Moorpark. These are picked at the firm ripe stage, and are halved and pitted but not peeled. Sulphuring is necessary, and the treatment is as described for the drying peaches.

Pears.—The Bartlett is the favoured variety for drying, and the fruit should be picked when mature, but still hard, and then ripened in boxes. When the pears are firm yellow ripe, the stalks are removed and they are peeled, halved, and the cores removed. The halves are placed on wooden trays with the cut side uppermost and then subjected to sulphur fumes. Because pears absorb sulphur very slowly, the minimum time of 12 hours is necessary, and sometimes double sulphuring for periods up to 30 hours is practised. When sulphuring is completed the pears are so soft they cannot be lifted from the trays. The trays are spread in the sun for two to three days, and then stacked and the top covered so that the final drying is in the shade. When dry the pears should have a clear golden semi-transparent appearance, and should be firm but not moist.

Apples for drying must be properly ripe and crisp, but not mealy. Dunns, Cleos, Granny Smiths and Rokewoods have been successfully used in Western Australia. In commercial apple drying factories, fruit is peeled, cored and sliced by special machinery, and there has been on the market small hand operated machines suitable for use in the home. These machines save a lot of tedious work and there is no doubt that they turn out a more uniform product than when peeling and coring are done by hand. The apples are peeled and cored and then cut at right angles to the line of core into slices ¼in. to 5/16in. in thickness. By this method the majority of slices are in the form of rings, and this form has been accepted as ideal for dried apples. The cut fruit should be prevented from coming into direct contact with iron as an objectionable blue stain is likely to appear on those portions which have touched any iron surface. Sliced apples discolour very quickly on exposure to air, and unless they can be sulphured immediately after cutting, it is advisable to keep the slices immersed in a one per cent. brine solution (made by adding 1 lb. of salt to 10 gallons of water) or in a solution of potassium meta-bisulphite (1 lb. to 40 gallons). This latter solution imparts a considerable amount of sulphur dioxide to the apple slices and for short storage will obviate the need for further sulphuring. If the dried apples are intended for long storage, however, the sulphur dioxide content must be kept much higher and it is advisable to subject the prepared slices to sulphur fumes as recommended for other tree

fruits, and for a period of 45 to 50 minutes. After sulphuring, if a dehydrator is not available, the slices are spread on netting or wooden trays and dried in the sun. They should be dried as quickly as possible, and it is advantageous to turn them several times during the day. When nearly dry, bulk the fruit from six trays to one tray and resulphur in the chamber for one hour. The dried fruit is placed in sweat boxes for a week, and then stored in airtight containers away from the light.

All dried fruits are liable to attacks by insects, such as weevils and dried fruit moths, and unless protection is afforded from these pests, a great part of the stored dried fruit may be damaged or destroyed. Dried fruit should be stored in airtight containers as soon as possible after drying, and to ensure that no insects or insect eggs are present at the time of packing, they should be treated with a fumigant such as Ethyl formate. This substance is manufactured in Australia, and sold under the trade name of Eranol Z.3. It is a volatile liquid, and is applied to the fruit at the time of packing, and immediately before being sealed. Half a teaspoonful per 20 lbs. of fruit is a suitable quantity to apply.

TREATMENT OF DRIED FRUITS PRIOR TO USE.

Dried tree fruits, particularly apricots, peaches and prunes, should be soaked for a considerable time before cooking. Use plenty of water, and soak for at least 24 hours. The fruit should then be allowed to come to the boil slowly in the water in which it was soaked, and boiled gently till plump and tender. The sugar should be added just before the cooking process is completed.

Soybean Inoculation Experiment.

W. P. Cass Smith, Plant Pathologist, and H. L. Harvey, Assistant Plant Pathologist.

INTRODUCTION.

A crop which to date has been cultivated to only a limited extent and on the whole unsuccessfully in W.A., but whose potentialities are considerable, is the soybean. The many valuable qualities which make this legume suitable for human and stock food and the production of oils, paints, soaps, rubber substitutes, etc., have been demonstrated elsewhere and are well known.

Like other legumes the soybean grows in association with bacteria which stimulate the formation of nodules on its roots and which enable such plants to obtain their supplies of nitrogen from the air. The bacteria are therefore an important factor in the nitrogen nutrition of the plant.

In the absence of these nodule-forming bacteria, the successful growth of a soybean crop is extremely unlikely in soils low in available nitrogen and probably the unsatisfactory results previously obtained locally with this legume have been largely due to this cause. In more fertile soils the soybean may grow satisfactorily even in the absence of these nodule-forming bacteria, but in this case it is obvious that growth can only take place at the expense of the available nitrogen in the soil. It is advisable, therefore, to inoculate the seed, before planting, with a culture of an effective strain of this organism and the experiment described was conducted to ascertain the relative effectiveness of a number of recently imported strains.

DETAILS OF EXPERIMENT.

In December, 1942, an experimental sowing of soybeans was made on swamp land at Jandakot, using three different strains of bacteria. With untreated (control) rows the experiment comprised, therefore, four rows which, when repeated at random seven times, gave a total of 28 rows. Each row measured ½ chain in length and the distance between rows was 4 links. The spacing between seeds was 4 inches and the variety used was Easycook, a variety suitable for both human and stock food. Superphosphate was applied at the rate of 4 cwts. per acre.

Treatments were:—

1. Seed inoculated with soybean culture ex Eastern States.
2. Seed inoculated with soybean culture ex U.S.D.A. (599).*
3. Seed inoculated with soybean culture ex U.S.D.A. (663).*
4. Seed not inoculated (control).

The seed was planted by hand on 15th December, 1942, and during planting, shade temperatures were in the vicinity of 100° F.

An inspection made on 1st January, 1943, showed the germination to be about 60 per cent. in all treatments.

RESULTS.

On 24th February, 1943, before plants had reached the flowering stage, treatments 2 and 3 in all seven blocks had made better growth and were slightly darker green in colour. On 18th March, 1943, six of the seven blocks were harvested and green weights taken at the flowering and early pod stage. At harvesting time treatment 2 appeared the best row in all blocks, being slightly taller than 3, its dark green foliage standing out in each block in contrast to the remaining rows. It reached about 2ft. 6in. in height. Treatments 1 and 4 were conspicuously smaller than 2 and 3, treatment 1 being slightly better than 4.

All six rows of each treatment were bulked after cutting and weighing, and a composite sample of each of the four treatments was taken for nitrogen analysis.

Green weights (average of six blocks) of rows, and nitrogen are presented in Table 1.

TABLE 1.

Treatment.	Average Green Weight per Row.	Moisture.	Nitrogen on Dry Weight.	Nitrogen per Row (Average).	
	ozs.	%	%	gm.	%
1	207	74·9	1·73	25·5	121
2	292	77·3	2·35	44·3	210
3	284	72·0	1·74	33·7	160
4 (control)	203	74·2	1·41	21·0	100
	P·05 = 43				

An analysis of the green yields showed that treatments 2 and 3 did not differ significantly, but both were better than 1 and 4. The percentage nitrogen obtained

* Obtained from the United States Dept. of Agriculture.

from the composite samples and the total amounts of nitrogen calculated per row were considerably greater for treatment 2 than for other treatments. This is in agreement with observed differences at harvesting time when the darker green colour of the treatment 2 plants indicated a higher nitrogen content. In the last column of Table 1, the nitrogen yields are expressed as percentages of the control.

On 30/4/43 block 7, which was representative of all blocks at flowering time, was harvested for seed yields. The stage of maturity of different treatments varied somewhat at this time. Treatments 2 and 3 were mature, largely defoliated and the pods were ready for threshing. Treatment 1 still carried a few green pods, while the plants of treatment 4 were less mature. It was necessary to dry off any green pods in the sun for a few days before threshing.

Table 2 shows the seed weights.

TABLE 2.

SOYBEAN SEED WEIGHTS.

Block.	Treatment.	Seed Weights.				
		Per Row.		Per Acre.	Per Acre.	%
		lbs.	ozs.	lbs.	bushels.	
7	1	1	11	844	14	108
7	2	2	10	1,325	22	168
7	3	1	14	938	16	120
7	4	1	9	781	13	100

The seed yields strongly support the evidence already presented—that treatment 2 is superior to all the others. The weight of seed harvested per row was considerably greater from treatment 2 than from the remainder, being the equivalent of 22 bushels per acre compared with 13 bushels for the control. The yields are compared on a percentage basis in the last column. It is interesting to note that the high nitrogen content in treatment 2 in the green stage is reflected in the high seed yields in that treatment, but the percentage nitrogen of the seed is only slightly higher than that of the "control" seed. (See seed analysis.)

Under the conditions of the above experiment, the strain of bacteria used in treatment 2 gave the most satisfactory results. This conclusion is drawn from the following observational and experimental evidence:—

1. At flowering time growth of these plants was generally more satisfactory and in particular the foliage colour was a conspicuous dark green which contrasted with that in the other treatments.
2. The percentage nitrogen was higher.
3. The amount of nitrogen per row was higher.
4. The seed yield was higher.

SOYBEAN SEED ANALYSIS.

As no analyses have been done previously on locally grown soybean seed, the opportunity was taken of using, for this purpose, some of the seed harvested in

the above experiment. Two samples were taken, viz., one from treatment 2 and one from treatment 4 (control) and the results are presented below.

	Treatment 2.	Treatment 4.
	%	%
Moisture (dried at 98°C)	11.56	11.62
Total Ash	5.87	5.86
Total Nitrogen (reported as N)	6.86	6.77
Calcium (Ca)	0.15	0.18
Phosphate (P_2O_5)	0.95	1.37
Potash (K_2O)	2.52	2.53

All figures on dry basis.

ACKNOWLEDGMENTS.

Statistical analysis of the results, and chemical analyses, were respectively carried out by the Deputy Conservator of Forests, and the Government Analyst, to whom the authors' thanks are given. Grateful acknowledgment is also given to Messrs. Coverley Bros., of Jandakot, who made available and prepared the land used in the experiment.

Apple Storage Experiments—Effect of Skin Coatings.

Report on Common Storage Experiment Carried Out at Perth during 1943 Season.

TREATMENT OF GRANNY SMITH APPLES WITH CASTOR OIL-SHELLAC SOLUTION.

T. C. MILLER, Horticultural Adviser.

Following work carried out in the Eastern States in previous years, an experiment was carried out in Western Australia this year by the coating of 1500 loose cases of Granny Smith apples with an alcoholic solution of castor oil and shellac, the intention being to ascertain to what extent the success obtained in the Eastern States, using the method followed, will apply to the Granny Smith variety under conditions ruling in this State. The fruit was processed at the Murray Street depot of the Apple and Pear Marketing Board, and held in common store at the same premises.

The solution used for treating the fruit was a four in one mixture of castor oil and dewaxed shellac made up into a 10 per cent. solution with 95 per cent. alcohol. This solution was quite mobile and drained freely from the dipped fruit which dried out in about an hour, and a thin coating of the oil and shellac remained on each apple. Once dry the film of oil is scarcely noticeable in appearance and gives very little if any taste to the fruit.

The procedure adopted was as follows:—

Twenty-five open slatted white wood picking boxes were used for dipping and the fruit was transferred to these as gently as possible. This was performed when the apples were in dump cases by placing the dipping box right over the opened case, inverting both together, and simply withdrawing the case. When the fruit was provided in white wood picking boxes it was more difficult to transfer the

fruit carefully, but this was carried out by placing the dipping box on top of the open end of the picking case, carefully tipping the two together until both lay on the ground, then raising the picking box to an angle of about thirty degrees while holding both boxes firmly together. At this angle most of the fruit passed gently down into the dipping box and on slowly continuing the movement until the picking box was inverted, the few remaining apples rolled into the lower box.

The solution was contained in a galvanised iron tank of approximately 20 gallons capacity and one case was dipped at a time, by simply lowering it into the solution until all apples were immersed and immediately withdrawing it and holding it over the tank for 10 seconds to drain. After dipping, the boxes were placed to drain further on a set of rollers over a corrugated iron draining table, where they remained for several minutes, then the apples were tipped gently into a hopper where they were sorted and transferred to cases to be stored. A minimum time of two hours was allowed for fruit to dry out properly after sorting, as stacking before being quite dry has a deleterious effect on the keeping quality of the fruit. The solution from the corrugated iron table drained back into the dipping tank, and the alcoholic solution was maintained at constant strength by periodically adding alcohol to make up for evaporation.

STORAGE CONDITIONS.

The fruit was stored in a corner of the shed, one quarter being closely stacked, and the remainder slatted and well ventilated. No thermograph was available to install with the fruit, but temperatures were obtained from the Meteorological Bureau which is close to the store (see table 1). The fruit was obtained partly from Karragullen and partly from Donnybrook.

TABLE 1.

TEMPERATURES AT PERTH, 1943.

Week Ending.	Weekly. Maximum. °F	Weekly. Minimum. °F	Weekly. Mean. °F	Monthly. Mean. °F
May 7	79	46	62	
„ 14	78	42	59	
„ 21	81	47	61	59
„ 28	71	44	57	
June 4	72	42	57	
„ 11	76	47	58	
„ 18	66	41	54	57
„ 25	69	44	56	
July 2	69	50	58	
„ 9	66	41	53	
„ 16	64	43	53	53
„ 23	64	38	53	
„ 30	67	36	52	
Aug. 6	63	41	52	
„ 13	69	43	55	
„ 20	66	44	54	54
„ 27	73	44	55	
Sept. 3	68	42	54	
„ 10	70	45	58	
„ 17	70	46	57	57
„ 24	68	41	55	
Oct. 1	77	44	53	

RESULTS.

The first line to be treated was picked during the first week in May and held in the depot until May 18th, when dipping commenced. Subsequent lots of fruit to be treated were picked during the middle of May and towards the end of that month. The treatment was carried on with short interruptions and finished on the 1st June. In general, the condition of the fruit treated was not very satisfactory, and that treated during the last few days was rather mature and some of it quite yellow. Bruises and blemishes were prevalent throughout.

The first inspection of the fruit took place on 2nd July, a month after dipping was completed, and at that time all lines were holding well, and seemed to have matured only very little since treatment, while the untreated controls had yellowed appreciably. No sign of undesirable flavours was apparent. Breakdown, due to bruising, and some rots which had commenced before treatment, were retarded by the action of the solution.

Two weeks later on 16th July, it was observed that there was a tendency of a change in flavour. The typical Granny Smith flavour was not longer present, although no distinct off flavours had developed. The fruit was still crisp, green and juicy, but actually the controls possessed a fuller and better flavour, and were still in good condition.

On the 6th August considerable time was spent in inspecting, sectioning and tasting the apples in various conditions found in the stack. In general, although the good colour of the fruit had been maintained, wilting had been almost eliminated, and it still appeared to be in prime condition. Alcoholic and breakdown flavours had commenced to appear. At this date, the controls were very yellow, wilting had commenced, and there were signs of internal breakdown in sizes of 3-inch and over. The smaller sizes were, however, much superior in flavour to any of the treated fruit.

Flavours apparent in the treated fruit at this period could be placed roughly into four classes, viz.:—

1. Fruit which was very much over-mature for processing at the time of dipping, and which was suffering from suffocation of the tissues, and showing distinct signs of breakdown and browning of the internal tissues. The flavour was typical of that of fruit which is commencing to breakdown. It is presumed that the reason for this condition is the fact that the fruit had reached an advanced stage of maturity when processed, and that the carbon dioxide forming in the fruit had been prevented from escaping by the film of oil and shellac, leading to suffocation and degeneration of the tissue.
2. Fruit which was apparently at the optimum stage of maturity for processing, and which appeared at that time to be a little yellow, but which had maintained its condition up to 6th August, and no undesirable flavours had developed. With regard to this type it is pointed out that this fruit was then quite yellow, no breakdown had commenced, but there was no flavour typical of the variety.
3. Fruit which was green at the time of processing, and which, without developing any undesirable flavour, had what may be termed a grassy taste.
4. Fruit which was green when processed, and which had since developed distinct alcoholic flavours.

The reason for the flavours developed in the 3rd and 4th classes is presumably that during the process of ripening, insufficient oxygen had been able to enter the skin, partly due to lack of ventilation in the stack, and partly to too thick a coating of oil shellac on the surface, causing anaerobic respiration to set in with a consequent production of alcohols and alcoholic flavours. It may be noted that some of these apples in class 4 had a distinct pineapple taste. Most apples of the large sizes, 3in. and over, showed traces of development of core flush at this time.

The browning of the tissue commencing from the core and spreading outwards (core flush) was slightly more prevalent in the treated than untreated fruit, and followed the incidence of the distinct alcoholic flavour and over maturity.

Following on this report, it was decided to pick over and pack out the treated lines. Seen on the bench, although there was considerable variation from very green to very yellow, by far the greater part of the fruit appeared well coloured and prime. It must be remembered that the original fruit at the time of treating consisted of very mixed grades and colours. Off flavours at this time were apparently not noticeable enough to affect to any extent the market value of the line. A report received from the Marketing Officer of the Apple and Pear Board at this period reads as follows—

Total waxed, 1448 (loose bushels).

Total Packed (All grades)	795 cases
Rejects in packing above	191 „
Rots (Tipped)	86 „
Held in store for further experiment ..	122 G. Smith
	1 Demo.

Note: Eighty-six cases were tipped but if fruit had been in sound condition it would have equalled approximately 150 cases.

The fruit held in store for further experiment was ultimately tipped on October 1st.

The sales of these apples were at Board rates, compatible with Board prices as at the time of sale.

The above fruit when packed was at its final stage for keeping, therefore the reason for packing and marketing. Fruit was showing internal breakdown in the larger sizes. No comments were passed by the general public in regard to any tastes or breakdown.

GENERAL REMARKS.

1. The cost of treatment (labour and materials) per packed case at the end of storage period was approximately 2s.

2. The maximum useful storage period was 12 weeks.

3. Better results should be obtained by treating a uniform line of fruit of 2½in. and 2¾in. sizes about two weeks earlier and immediately after picking.

4. Less mature fruit coated with a slightly weaker mixture may be more suitable for Western Australian conditions, and should hold longer in common store.

Erratum.

Jnl. Dept. Agric., W.A., Vol. 20, No. 1, page 4, last line—0.4 should read 0.24 per cent. P_2O_5.

The Official Australian Pure Bred Dairy Cattle Production Recording Scheme.

WESTERN AUSTRALIAN RESULTS.

M. CULLITY, Superintendent of Dairying; B. H. DRAKES, Recording Officer.

Farmers are accustomed to look forward to the publication each year of the production figures of the pure-bred herds, in order to study the results achieved by the breeders. In this State, owing to the educational effect of the Dairy Cattle Improvement Act and other activities, the proportion of bulls in use which are pure-bred is over 70 per cent. A large proportion of these are "standard" bulls, being the progeny of cows which have been tested and have given more than the standard for the age at testing. The owners of commercial herds therefore have a keen appreciation of the value of testing and the need for prepotent sires from high producing blood lines if the quality of their herds is to be improved. The failure of stud breeders over a period of years to achieve any substantial improvement in the production of their herds is disappointing, while the success achieved by numbers of commercial dairymen in obtaining average productions in their herds surpassing those of many pure-bred herds is a direct and forcible challenge to breeders who aspire to supply herd sires for these grade herds.

A new approach in this matter is needed, otherwise the value of the pure-bred herds will be discounted to such an extent that retrogression will set in. It is apparent from a study of the results year by year, that too many poor quality females are reared. This suggests that the herd sires have not been up to quality. If this is the case, endeavours must be made to organise a system whereby an earlier appreciation of the value of each bull may be obtained. The tabulation of the performances of all tested cows according to their sires would provide basic information regarding the probable success or failure of all new bulls. It is hoped that a start will be made with the tabulation of this information soon after the cessation of hostilities.

The average production of pure-bred cows under test is shown in Table 1.

TABLE I.

AVERAGE PRODUCTION OF PURE-BRED COWS UNDER OFFICIAL TEST.

Year.	Number of Cows Completing Test.	Average Butter-fat per Cow.
		lbs.
1934–35	305	320·26
1935-36	367	297·17
1936–37	319	300·87
1937–38	333	298·08
1938–39	375	292·40
1939–40	382	305·88
1940–41	372	298·38
1941–42	290	322·84
1942–43	294	321·27

It will be noted that the average for the year is only 1.57 lbs. below the record production of 1941-42 and therefore can be regarded as satisfactory in view of the unsettled conditions and difficulties of war time.

A total of 315 cows in 21 herds were tested during the year and of these 21 were withdrawn before they were tested for 150 days, leaving 294 to be included in the averages. A number were withdrawn from test after the 150 days, but before the completion of a full lactation period.

The percentage of cows passing the standard declined slightly from the previous year, although better than in earlier years. The details are shown in Tables 2 and 3.

TABLE II.

PERCENTAGE OF COWS PASSING STANDARD.

Year.	A.I.S.	Guernsey.	Jersey.	Total.
1942–43	67·6	67·9	55·0	64·3
1941–42	73·1	68·3	59·7	68·3
1940–41	52·0	61·0	51·0	54·0
1939–40	48·0	77·5	64·2	59·2
1938–39	53·8	71·4	55·2	57·9
1937–38	59·1	68·7	35·6	53·1

The bulk of the withdrawals referred to above were Jerseys and therefore the fall in the percentage passing the standard is probably higher than would have been the case had misfortune not been encountered in one herd.

TABLE III.

COWS PASSING STANDARD.

Age Class.	A.I.S.		Guernsey.		Jersey.		All Breeds.	
	No. of Cows. Tested.	No. Passing. Standard.	No. of Cows Tested.	No. Passing Standard.	No. of Cows Tested.	No. Passing Standard.	No. of Cows Tested.	No. Passing Standard.
Mature	41	24	27	17	22	5	90	46
Senior, 4 years	6	4	5	3	4	3	15	10
Junior, 4 years	16	10	6	6	3	3	25	19
Senior, 3 years	8	7	5	3	7	4	20	14
Junior, 3 years	18	12	6	4	8	6	32	22
Senior, 2 years	18	8	2	1	14	8	34	17
Junior, 2 years	35	31	21	15	22	15	78	61
Totals	142	96	72	49	80	44	294	189
Percentage Passing Standard	67·6		67·9		55·0		64·3	

The effect of the withdrawals of these cows from test before the completion of the full period can be seen plainly in the mature class of the Jerseys, where only five of the 22 cows whose figures were included, passed the standard.

One very pleasing feature of this table is the relative success achieved by the junior two-year old heifers. In this class 61 of a total of 78 tested passed the

standard. It will be noted with interest also that the productions of both the junior and senior two-year classes of Jerseys were better than both the Shorthorns and Guernseys. (See Table 4.) This may indicate greatly improved performances from this breed in future years.

TABLE IV.

AVERAGE BUTTER-FAT PRODUCTION IN EACH CLASS.

Age Class.	Standard.	A.I.S.		Guernsey.		Jersey.		All Breeds.	
		No. of Cows.	Average Butter-fat.	No. of Cows.	Average Butter-fat.	No. of Cows.	Average Butter-fat.	No. of Cows.	Average Butter-fat.
	lbs.		lbs.		lbs.		lbs.		lbs.
Mature	350	41	378·81	27	396·64	22	268·41	90	356·19
Senior, 4 years	330	6	356 42	4	347·23	4	356·42	15	355·37
Junior, 4 years . .	310	16	335·43	6	415·82	3	376·66	25	359·67
Senior, 3 years .	290	8	354·10	5	293·46	7	338·43	20	333·46
Junior, 3 years . .	270	18	308·60	6	431·55	8	415·50	32	312·76
Senior, 2 years ...	250	18	290·21	2	279·42	14	321·65	34	302·52
Junior, 2 years .	230	35	276·72	21	250·40	22	280·37	78	270·66

A perusal of this table shows that the Jersey mature class, discussed earlier, was the only one which did not exceed the standard. New records were established during the year.

Senior Three-year old Class.

"Juadine Peerless Lily 13th" (Jersey) owned by Miss L. G. Hancock, of Harvey, produced 10,364 lbs. of milk, 6.25 per cent. average test and 648.60 lbs. of butter-fat in 273 days.

This established records for:—

1. All breeds, Senior three-year olds.
2. Jersey, Senior three-year olds.
3. W.A. Bred, Senior three-year olds.

Junior Two-year old Class.

"Juadine Queen" (Jersey) owned by Miss L. G. Hancock of Harvey, produced 6,789 lbs. of milk, 6.21 per cent. average test and 421.64 lbs. of butter-fat in 273 days, which is a record for Jerseys in this class.

"Juadine Peerless Lily 13th" and "Juadine Queen" are by the imported bull "Austral Park Wonderful Standard" which proved to be the leading sire for the season.

AVERAGE PRODUCTION OF DAUGHTERS OF SIX HERD SIRES.

Name of Bull.	Sire.	Dam.	Average Production of Six Best Daughters.		No of Daughters	Average Production.	
			Without Allowances.	With Allowances.		Without Allowances.	With Allowances.
			lbs. butter-fat.	lbs. butter-fat.		lbs. butter-fat.	lbs. butter-fat.
Austral Park Wonderful Standard (12423)	Ellerdale Wonderful Masterman (11561)	Ellerdale Wonder's Golden (47992)	447·89	533·49	7	430·38	516·76
Blacklands Jean's Supreme (1871)	Fussy's Monarch of Hillview (493) (I.M.S.H.B.)	Jean 7th of Blacklands (7425) (I.M.S.H.B.)	494·28	513·73	15	378·38	420·74
Koojan Golden Prosper (2283)	Koojan Golden Governor (595)	Koojan Bonnie Jean (1612)	494 44	502·72	12	425·00	435·91
Parkview Guardian (2557)	Parkview Guardsman (183)	Parkview Eva 12th (1157) ...	454·30	476·12	15	389·39	415·91
Grass Vale Gold Boy (14684)	Belgonia Gold Boy (12458) . .	Grass Vale Lady Fowler 17th (48536)	411·68	468·89	14	357·54	435·60
Parkview Commodore (306)	Jean's Monarch of Blacklands (869) (I.M.S.H.B.)	Mayflower 9th of Parkview (8065) (I.M.S.H.B.)	425·17	443·48	11	371·19	398·67

TABLE VI.

COWS WHICH COMPLETED TEST DURING THE TWELVE MONTHS ENDED 30TH JUNE, 1943.

Name of Cow.	Breed.	Herd Book No.	Date of Birth.	Date of Entry to Test.	No. of Days in Test.	Weight of Milk Last Day of Test.	Weight of Milk for Period.	Average Test.	Weight of Butter Fat for Period.	Owner.	Sire.
COWS UNDER 2½ YEARS—STANDARD 230 LB. BUTTER-FAT.											
						lb.	lb.	%	lb.		
Wallatin Fairy 3rd	A.I.S.	....	17–5–40	5–5–42	273	40	11,370	3·88	441·83	B. W. Prowse ...	Summerlea Pioneer
Juadine Queen	Jersey	....	20–5–40	25–8–42	273	18	6,789	6·21	421·64	Miss L. G. Hancock	Austral Park Wonderful Standard (12423)
Camden Ariadne	do.	...	10–8–40	19–7–42	273	13·5	5,815	6·65	386·93	C. E. Kruger .	Greenmount Golden Sultan (14688)
Denmark Golden Valencia 2nd	Guernsey	8535	15–9–39	10–11–41	273	14	6,672	5·78	385·81	Denmark Research Station	Koojan Ace's Goldseeker (3431)
Denmark Golden Valencia	do.	8534	15–9–39	28–2–42	273	19	7,242	5·16	374·37	Denmark Research Station	Koojan Ace's Goldseeker (3431)
Wooroloo Golden Girl	A.I.S.	....	27–6–39	20–10–41	273	26	8,718	4·06	354·64	Wooroloo Sanatorium Farm	Glanavon Genius (3957)
Camden Diana	Jersey	...	10–9–40	27–7–42	273	15·5	6,466	5·44	352·14	C. E. Kruger .	Greenmount Golden Sultan (14688)
Grass Vale Silvermine	do.	...	6–11–40	13–9–42	273	15	5,505	6·26	344·90	R. H. Rose . ..	Grass Vale Gold Boy (14684)
Grass Vale Magnolia	do.	....	29–6–39	28–11–41	273	22	6,936	4·93	342·46	R. H. Rose .. .	Grass Vale Gold Boy (14684)
Koojan Golden Jewel	Guernsey	....	12–3–40	3–8–42	273	18	6,894	4·91	338·68	A. W. Padbury .	Koojan Beau Ideal
Denmark Anna	do.	....	24–9–39	7–11–41	273	20	5,790	5·80	336·20	Denmark Research Station	Koojan Ace's Goldseeker (3431)
Glanavon Girl 4th	A.I.S.	....	10–11–39	12–4–42	273	25	8,775	3·81	334·84	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Glanavon Topsy	do.	....	27–9–39	16–3–42	273	22	8,376	3·96	331·93	D. Bevan & Sons .	Tipperary President (5335)
Glanavon Daphne 5th	do.	....	12–4–39	9–10–41	240	26	6,900	4·79	331·11	D. Bevan & Sons ...	Blacklands Jean's Supreme (1871)
Juadine Julienne	Jersey	...	2–3–40	28–8–42	273	13·5	6,385	5·13	327·90	Miss L. G. Hancock	Austral Park Wonderful Standard (12423)
Claremont Poppy 19th	A.I.S.	....	8–7–40	27–9–42	273	27	7,791	4·18	325·72	Claremont Hospital for Insane	Wooroloo Triumph 4th (3627)
Juadine Peerless Lily 17th	Jersey	....	18–12–39	28–4–42	273	15	5,175	6·28	325·30	Miss L. G. Hancock . .	Austral Park Wonderful Standard
Grass Vale Lady Fowler 31st	do.	....	17–8–40	6–9–42	273	17	5,871	5·46	320·84	R. H. Rose	Grass Vale Gold Boy (14684)
Wooroloo Lilac 2nd	A.I.S.	....	18–12–39	17–6–42	273	19	7,647	4·16	318·25	Wooroloo Sanatorium Farm	Wooroloo Triumph's Heir
Glanavon Maggie	do.	....	7–8–39	6–2–42	273	27	8,031	3·94	317·15	D. Bevan & Sons ..	Tipperary President (5335)
Wallatin Queen Regent	do.	....	4–5–40	7–5–42	273	22·5	7,727	4·02	310·92	B. W. Prowse ...	Summerlea Pioneer
Travalgan Lady Eion 7th	Jersey	...	22–6–40	16–6–42	273	15	5,565	5·51	306·69	W. H. & T. F. Robinson	Travalgan Northern Airman (13312)
Grass Vale Golden Cream 22nd	do.	....	18–6–40	18–8–42	273	13	5,049	6·02	304·22	R. H. Rose	Grass Vale Gold Boy (14684)
Travalgan Starbright 13th	do.	....	6–6–40	12–6–42	273	15	5,475	5·51	302·17	W. H. & T. F. Robinson	Travalgan Northern Airman (13312)
Wooroloo Dawn 2nd	A.I.S.	...	9–10–39	8–4–42	273	19	6,777	4·40	298·43	Wooroloo Sanatorium Farm	Wooroloo Red Lad (5418)
Yanget Show Girl	do.	....	20–1–40	30–4–42	273	23·5	7,270	4·10	298·34	B. W. Prowse ...	Leylands Defiance (2380)
Brookfields Glorion	Guernsey	8384	2–2–40	15–3–42	273	17·5	5,122	5·81	297·77	P. G. Hampshire & Son	Brookfields Baron (3936)
Grass Vale Golden Maggie....	Jersey	....	5–10–39	13–10–41	273	18	5,754	5·13	295·47	R. H. Rose	Grass Vale Gold Boy (14684)

Glanavon Gwen	A.I.S	....	21-7-40	15-9-42	273	23	6,759	4·25	287·62	D. Bevan & Sons .	Parkview Commodore (306)
Travalgan Starbright 9th ...	Jersey	....	23-5-40	7-6-42	273	15	5,115	5·59	286·02	W. H. & T. F. Robinson	Travalgan Northern Airman (13312)
Koojan Ideal's Pixie ...	Guernsey	813	10-9-39	28-1-42	273	14	4,812	5·88	283·06	A. W. Padbury ...	Glenburnie Ideal (Imp.) (2548)
Claremont Mable 18th	A.I.S.	....	15-4-40	2-10-42	273	25	6,975	4·04	282·10	Claremont Hospital for Insane	Wooroloo Jean 2nd's Guardian (4488)
Wooroloo Sunlady 2nd	do.	....	25-3-40	9-4-42	273	19	6,207	4·53	281·66	Wooroloo Sanatorium Farm	Wooroloo Red Lad (5418)
Maxwell Queen Ann	Guernsey	...	29-5-40	15-9-42	273	11	4,173	6·63	277·01	P. Berridge	Moongi Oliver (1495)
Tipperary Maggie 7th	A.I.S.	....	22-8-40	8-8-42	273	12	6,816	4·04	275·88	W. G. Burges ...	Liberton Venturer
Glanavon Rosina 4th	do.	....	24-9-40	18-8-42	273	20	7,260	3·76	273·51	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Claremont Maggie Morrison 39th	do.	....	5-7-40	30-9-42	273	26	6,618	4·10	271·55	Claremont Hospital for Insane	Wooroloo Triumph 4th (3627)
Brookfields Queen 8th	Guernsey	...	21-8-40	29-9-42	273	16	5,868	4·61	270·72	P. G. Hampshire & Son	Yarraview Clarinette
Claremont Maggie Morrison 36th	A.I.S.	....	24-2-40	11-8-42	273	24	6,462	4·17	269·97	Claremont Hospital for Insane	Westby Monarch (5404)
Lansdowne Jocelyn	Guernsey	....	15-7-40	1-10-42	273	12	5,256	5·09	267·70	A. W. Padbury .	Koojan Beau Ideal
Claremont Treasure 22nd	A.I.S.	...	25-6-40	26-9-42	273	24	7,062	3·78	267·37	Claremont Hospital for Insane	Wooroloo Triumph (3627)
Lenmoors Queen	do.	....	27-8-39	5-11-41	273	24	6,882	3·87	266·64	G. W. Marston	Longridge Blanche's Emblem (3344)
Claremont Poppy 18th	do.	...	26-1-40	16-6-42	273	18	6,324	4·19	265·49	Claremont Hospital for Insane	Westby Monarch (5404)
Glanavon Daphne 6th	do.	....	1-3-40	19-4-42	273	14	6,642	3·94	262·03	D. Bevan & Sons	Glanavon Franklyn (4829)
Claremont Clara 15th	do.	....	28-5-40	12-9-42	273	21	6,093	4·29	261·56	Claremont Hospital for Insane	Wooroloo Triumph 4th (3627)
Tipperary Dove 14th	do.	....	22-3-40	19-4-42	273	12	6,216	4·19	260·69	W. G. Burges ...	Liberton Venturer
Wooroloo Dainty 4th	do.	...	1-1-40	30-4-42	273	11	5,883	4·41	259·87	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Grass Vale Golden Cream 23rd	Jersey	....	2-8-40	19-9-42	273	11	4,413	5 84	257·99	R. H. Rose	Grass Vale Gold Boy (14684)
Denmark Golden Dawn 2nd	Guernsey	8527	2-4-40	15-8-42	273	8·5	4,330	5·94	257·35	Denmark Research Station	Koojan Ace's Goldseeker
Lansdowne Lady	do.	....	3-7-40	13-9-42	273	11·5	4,969	5·14	255·64	A. W. Padbury ..	Koojan Beau Ideal
Claremont Biddy 52nd	A.I.S.	....	10-6-40	18-9-42	273	27	6,591	3·83	252·77	Claremont Hospital for Insane	Wooroloo Triumph 4th (3627)
Claremont Star 22nd ...	do.	....	1-5-40	29-8-42	273	18	6,234	4·04	252·07	Claremont Hospital for Insane	Wooroloo Triumph 4th (3627)
Claremont Pinafore 12th	do.	....	25-7-40	29-9-42	273	18	6,534	3·84	251·35	Claremont Hospital for Insane	Westby Monarch (5404)
Travalgan Lady Eion 8th	Jersey	....	19-9-40	16-6-42	273	13	4,809	5·18	249·21	W. H. & T. F. Robinson	Glen Iris Golden Oxford (12694)
Brookfields Bonny	Guernsey	8378	3-3-40	8-5-42	273	16	4,803	5·17	248·79	P. G. Hampshire & Son	Yarraview Clarinette 2nd (4629)
Muresk Delicia	do.	....	15-5-40	7-6-42	273	13	5,259	4·48	246·76	Muresk Agricultural College	Denmark Damon
Claremont Maggie Morrison 38th	A.I.S.	....	7-6-40	6-9-42	273	24	6,492	3·77	245·30	Claremont Hospital for Insane	Claremont Max Hero (3802)
Thornlie Pearl's Idyll	Guernsey	9508	26-1-40	4-4-42	273	18	4,734	5·16	244·72	P. G. Hampshire & Son	Pleasant Hill Prince (4414)
Claremont Beauty 18th	A.I.S.	....	30-1-40	11-6-42	273	17	5,541	4·38	243·18	Claremont Hospital for Insane	Wooroloo Triumph 4th (3627)
Claremont Treasure 20th	do.	....	20-5-39	16-10-41	273	19	6,147	3·85	237·06	Claremont Hospital for Insane	Wooroloo Triumph 4th (3627)
Lansdowne Cream Lady	Guernsey	8826	3-10-39	22-10-41	273	11	4,323	5·47	236·77	P. G. Hampshire & Son	Koojan Ideal's Benefactor (4165)
Tipperary Beauty 11th	A.I.S.	....	20-9-40	1-8-42	273	9	5,727	4·01	229·66	W. G. Burges	Liberton Venturer
Grantham Easter Fairy 2nd	Jersey	....	22-5-40	30-10-41	240	12·5	3,960	5·50	217·83	J. A. Sears	Grantham Easter Oxford (14677)

HERD TESTING—*continued*

Name of Cow.	Breed.	Herd Book No.	Date of Birth	Date of Entry to Test.	No. of Days in Test.	Weight of Milk Last Day of Test.	Weight of Milk for Period.	Average Test.	Weight of Butter Fat for Period.	Owner.	Sire.
COWS UNDER 2½ YEARS—STANDARD 230 LB. BUTTER-FAT—*continued*.											
						lb.	lb.	%	lb.		
Claremont Whitby Maid 40th	A.I.S.	....	28-5-40	4-9-42	273	12	5,271	4·10	216·34	Claremont Hospital for Insane	Westby Monarch (5404)
Crantock Starbright's Reminder	Jersey	....	21-6-40	20-7-42	240	6	3,660	5·73	209·91	Mrs. G. H. Burnside	Crantock Starbright's Airman (15491)
Crantock Noble Bell	do.	...	11-8-40	11-9-42	240	8	3,840	5·25	201·66	Mrs. G. H. Burnside	Crantock Emminent's Noble (17405)
Muresk Rose Petal	Guernsey	....	13-1-40	22-5-42	273	7	3,951	5·00	197·70	Muresk Agricultural College	Muresk Homestead
Hopelands Northern Helena	Jersey	....	7-10-39	9-6-42	240	11	3,690	5·30	195·84	A. G. Scott	Travalgan Northern Noble (10124)
Grass Vale Silver Eve	do.	....	1-9-40	6-9-42	150	20	3,810	5·01	190·96	R. H. Rose	Clarendon Eyre Bing Boy 4th
Glanavon Melba 3rd	A.I.S.	...	11-11-40	20-9-42	273	9	4,167	4·27	178·27	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Grass Vale Lady Fowler 30th	Jersey	..	22-5-40	4-10-42	180	9	3,030	5·63	170 66	R. H. Rose	Grass Vale Gold Boy (14684)
Glanavon Ettie 3rd	A.I.S.	..	19-10-40	23-10-42	120	27	3,930	4·17	164·16	D. Bevan & Sons	Parkview Commodore (306)
Thornlie Lady May	Guernsey	...	16-11-39	4-11-41	180	11	3,330	4·91	163·68	R. J. Giles	Warrawong Wonder (4536)
Brookfield's Julia	do.	....	18-3-40	11-7-42	180	20	3,360	4·66	156·63	P. G. Hampshire & Son	Brookfields Baron
Maxwell Red Rose	do.	...	23-6-40	7-10-42	150	10	2,880	5·40	155·79	P. Berridge	Moongi Oliver (1495)
Lenmoors Milkmaid 2nd	A.I.S.	..	20-10-40	19-10-42	120	24	3,735	4·05	151·38	G. W. Marston	Lenmoors Gem (4977)
Denmark Briarette	Guernsey	....	24-9-40	31-7-42	273	5	2,715	5·08	138·21	Denmark Research Station	Koojan Ideal's Dictator
Glanavon Empress 4th	A.I.S.	...	24-7-40	1-9-42	150	10	2,820	4·61	130·08	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Denmark Jonquil	Guernsey	..	24-4-40	24-7-42	273	5	2,370	5·27	125·03	Denmark Research Station	Denmark Beau Ideal (4779)
Glanavon Sunbeam 15th	A.I.S.	...	30-10-40	18-10-42	120	15	2,520	3·95	99·63	D. Bevan & Sons	Parkview Commodore (306)
Lenmoors Joan 2nd	do.	...	5-8-40	25-11-42	90	21	2,310	3·85	89·10	G. W. Marston	Lenmoors Gem (4977)
Hopelands Master Belle	Jersey	....	18-8-40	12-11-42	90	6·5	1,095	5·13	56·28	A. G. Scott	Travalgan Northern Noble (10124)
Hopelands Jean	do.	..	19-9-40	3-11-42	90	14	1,800	3·08	55·56	A. G. Scott	Travalgan Northern Noble (10124)
Tipperary Dove 15th	A.I.S.	...	14-4-40	4-5-42	60	13	1,110	4·43	49·20	W. G. Burges	Liberton Venturer
Glanavon Nancy 5th	do.	..	29-12-40	20-10-42	30	37	1,110	4·11	45·69	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Tipperary Lovely 4th	do.	....	29-6-40	12-8-42	30	31	930	4·27	39·78	W. G. Burges	Blacklands Monarch's Commander
Glanavon Florrie 2nd	do.	...	4-5-40	17-10-42	30	31	930	4·25	39·54	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
COWS 2½ YEARS AND UNDER 3 YEARS STANDARD 250 LBS BUTTER-FAT.											
Camden Circe	Jersey	....	24-9-39	6-7-42	273	19	7,047	6·36	448·48	C. E. Kruger	Greenmount Golden Sultan (14688)
Capel Rosemay	A.I.S.	..	21-10-39	4-5-42	273	37	11,036	3·94	435·06	B. W. Prowse	Capel Star King (4672)
Juadine Sparkle's Achievement	Jersey	....	27-9-39	26-8-42	273	20	8,295	4·90	406·62	Miss L. G. Hancock	Austral Park Wonderful Standard (12423)
Wooroloo Faith	A.I.S.	....	10-1-39	14-12-41	273	28·5	9,040	4·35	393·38	Wooroloo Sanatorium Farm	Glanavon Genius (3957)
Camden Beauty	Jersey	..	9-9-39	8-7-42	273	13	6,144	6·36	390·78	C. E. Kruger	Greenmount Golden Sultan (14688)
Grass Vale Buttercup 7th	do.	....	9-9-39	6-8-42	273	20	6,870	5·43	373·64	R. H. Rose	Grass Vale Gold Boy (14684)
Juadine Peerless Lily 16th	do.	....	20-9-39	24-4-42	273	21·5	6,544	5·69	372·91	Miss L. G. Hancock	Austral Park Wonderful Standard (12423)
Glanavon Glenys	A.I.S.	....	14-10-39	1-9-42	273	27	9,171	4·05	372·32	D. Bevan & Sons	Tipperary President (5335)

Wooroloo Netta 2nd	do.	..	6-10-39	15-5-42	273	26	9,078	4·06	369·00	Wooroloo Sanatorium Farm	Glanavon Genius (3957)
Wooroloo Bess	do.	23231	16-5-39	17-3-42	273	29	8 997	4·08	367·64	Wooroloo Sanatorium Farm	Glanavon Genius (3957)
Camden Arachne	Jersey	....	9-9-39	6-7-42	273	14	5,997	6·12	367·10	C. E. Kruger	Greenmount Golden Sultan (14688)
Grass Vale Lady Fowler 28th	Jersey	....	8-10-39	27-7-42	273	18	5,934	6·06	359·78	R. H. Rose	Grass Vale Gold Boy (14684)
Glanavon Dahlia 8th	A.I.S.	....	9-12-38	28-10-41	273	28	9,534	3·69	352·38	D. Bevan & Sons	Glanavon Franklyn (4829)
Grass Vale Golden Maggie	Jersey	81629	5-10-39	26-9-42	273	17	6,306	5·52	348 52	R. H. Rose	Grass Vale Gold Boy (14684)
Brookfields Prudence	Guernsey	8339	13-1-40	1-9-42	273	15	5,280	6·18	326·44	P. G. Hampshire & Son	Yarraview Clarinette (4628)
Grass Vale Lady Fowler 29th	Jersey	....	9-9-39	26-8-42	273	16	5,898	5·44	321·03	R. H. Rose	Grass Vale Gold Boy (14684)
Glanavon Rose 2nd	A.I.S.	....	13-11-39	28-4-42	273	19	7,287	4·09	298·38	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Glanavon Pansy 5th	do.	...	13-6-39	29-4-42	273	18	7,704	3·86	298·05	D. Bevan & Sons	Glanavon Franklyn (4829)
Travalgan Starbright 8th	Jersey	79296	6-7-39	11-3-42	273	15	5,025	5·76	289·49	W. H. & T. F. Robinson	Glen Iris Golden Oxford (12694)
Glanavon Goldilocks	A.I.S.	....	7-6-39	16-2-42	273	21	7,593	3·79	288·19	D. Bevan & Sons	Glanavon Franklyn (4827)
Westby Lupin 18th	do.	....	27-9-39	25-4-42	273	16	6,288	4·29	270·12	Burkett & Brown	Westby Monarch (5404)
Glanavon Empress 3rd	do.	...	21-8-39	20-3-42	273	17	6,411	4·19	268 80	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Crantock Starbright Delphinium	Jersey	....	30-4-39	28-2-42	273	21	6,103	4·35	265·62	Mrs. G. H. Burnside	Congelin Eminent's Golden (13623)
Wooroloo Rare Gem 2nd	A.I.S.	..	22-4-39	27-3-42	273	9	6,447	4·10	264·36	Wooroloo Sanatorium Farm	Glanavon Genius (3957)
Travalgan Starbright 7th	Jersey	79295	25-5-39	27-4-42	273	12	4,821	5·35	258·40	W. H. & T. F. Robinson	Glen Iris Golden Oxford (12694)
Crantock Golden Juliet	do.	....	30-4-39	17-3-42	240	26	5,460	4·67	255·09	Mrs. G. H. Burnside	Congelin Eminent's Golden (13623)
Yanget Pretty Maid 4th	A.I.S.	....	7-10-39	30-6-42	240	9	6,000	4·13	247·80	W. G. Burges	Leylands Defiance (2380)
Wooroloo Fussy 2nd	do.	....	21-5-39	19-2-42	210	12	5,880	4·18	246·27	Wooroloo Sanatorium Farm	Glanavon Genius (3957)
Westby Dahlia 2nd	do.	..	26-8-39	29-4-42	273	18	6,504	3·73	243·18	Burkett & Brown	Westby Searchlight
Brookfields Queen 6th	Guernsey	8390	2-3-39	6-3-42	273	10	4,755	4·88	232·41	P. G. Hampshire & Son	Brookfields Baron (3936)
Claremont Blossom 32nd	A.I.S.	....	16-2-40	3-9-42	273	22	5,916	3·85	227·81	Claremont Hospital for Insane	Claremont Max Hero (3822)
Hopelands Silverbelle 4th	Jersey	....	4-5-39	16-12-41	273	12·5	4,634	4·45	206·64	A. G. Scott	Melrose Sultan (6930)
Travalgan Lady Eion 6th	do.	79293	19-8-39	1-8-42	180	20	4,290	4·50	193·07	W. H. & T. F. Robinson	Glen Iris Golden Oxford (12694)
Greenmount Milkmaid 3rd	do.	..	16-8-39	1-5-42	210	7	3,540	4·44	157·50	A. G. Scott	Bellefaire Bonaparte's Bonetienne (9224)
Lenmoors Della	A.I.S.	...	7-7-39	20-3-42	210	8	3,592	3·92	141·03	G. W. Marston	Longridge Blanche's Emblem (3344)
Tipperary Maggie 6th	do.	....	17-7-39	21-4-42	150	11	2,955	4·73	140·04	W G. Burges	Wooroloo Melba's Triumph
Lenmoors Fancy	do.	....	23-7-39	1-4-42	120	31	3,945	3·09	122·04	G. W. Marston	Longridge Blanche's Emblem (3344)

COWS 3 YEARS AND UNDER 3½ YEARS STANDARD 270 LBS OF BUTTER-FAT.

Glanavon Empress 2nd	do.	..	5-7-38	8-10-41	273	15	10,935	4·19	458·68	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Wooroloo Rosebud 3rd	do.	....	29-5-39	22-6-42	273	19	10,617	4 02	427 68	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Denmark Dame	Guernsey	6960	17-6-38	11-11-41	273	30·5	10,311	4·08	420·77	Denmark Research Station	Koojan Golden Prosper (2253)
Koojan Ideal's Bluebell	do.	8807	15-1-39	14-6-42	273	14	6,552	5·86	384·47	A. W. Padbury	Glenburnie Ideal (Imp.) (2548)
Glanavon Doris 7th	A.I.S.	....	2-12-38	26-5-42	273	20	9,570	4·00	383·10	D. Bevan & Sons	Glanavon Franklin (4829)
Glanavon Thelma 3rd	do.	....	25-1-39	5-4-42	273	15	9,795	3·84	377·05	D. Bevan & Sons	Parkview Commodore (306)
Grass Vale Buttercup 5th	Jersey	....	22-6-39	11-7-42	273	11	6,213	6·00	373·30	R. H. Rose	Grass Vale Gold Boy (14684)
Travalgan Lady Mint 8th	do.	79294	3-5-39	16-6-42	273	16	6,408	5·63	361·14	W. H. & T. F. Robinson	Glen Iris Golden Oxford (12694)
Tipperary Beauty 7th	A.I.S.	....	27-7-39	2-10-42	273	23	7,989	4·47	357·25	W. G. Burges	Wooroloo Melba's Triumph (4491)

HERD TESTING—*continued.*

Name of Cow.	Breed.	Herd Book No.	Date of Birth.	Date of Entry to Test.	No. of Days in Test.	Weight of Milk Last Day of Test.	Weight of Milk for Period.	Average Test.	Weight of Butter Fat for Period.	Owner.	Sire
COWS 3 YEARS AND UNDER 3½ YEARS. STANDARD 270 LB. OF BUTTERFAT—*continued*											
						lb.	lb.	%	lb.		
Tipperary Beauty 6th	A.I.S.	....	8-8-38	31-12-41	273	14	7,962	4·43	353 33	W. G. Burges	Newstead Tourist (3419)
Glanavon Doris 6th	do.	.	9-11-38	15-1-42	273	15	8,160	4·21	343·55	D. Bevan & Sons	Parkview Commodore (306)
Camden Patsy	Jersey	..	27-6-39	2-7-42	273	11	5,108	6·62	338·66	C. E. Kruger	Greenmount Golden Sultan (14688)
Glanavon Doris 8th	A.I.S.	...	4-12-38	9-2-42	273	16	8,058	4·00	322·37	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Wooroloo Joy 4th	do.	...	6-7-38	17-9-41	210	18	6,810	4·68	318·90	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Glanavon Nancy 2nd	do.	....	2-12-38	4-6-42	240	20	7,770	4 07	316·77	D. Bevan & Sons	Glanavon Franklyn (4829)
Crantock Starbright's Princess	Jersey	....	26-7-39	28-8-42	273	17	5,361	5·87	314·87	Mrs. G. H. Burnside	Crantock Starbright's Airman (15481)
Grantham Easter's Junette	do.	66775	20-6-38	5-12-41	210	24	6,563	4 50	295·92	J. A. Sears	Clarendon Eyre Oxford Pioneer (11484)
Claremont Blossom 31st	A.I.S.	....	4-2-40	14-8-42	273	23	7,389	3 86	285 88	Claremont Hospital for Insane	Westby Monarch (5404)
Muresk Angelica	Guernsey	9101	10-9-39	29-9-42	273	11	5,403	5·16	279 17	Muresk Agricultural College	Muresk Homestead (2075)
Claremont Cherry 17th	A.I.S.	..	18-1-39	8-6-42	273	18	6,774	4 00	270·27	Claremont Hospital for Insane	Wooroloo Triumph 4th (3627)
Grantham Air Lady 5th	Jersey	66771	29-5-38	25-11-41	210	23·5	5,100	5·16	263·64	J. A. Sears	Clarendon Eyre Oxford Pioneer (11484)
Glanavon Golden Girl 3rd	A.I.S.	...	18-9-38	28-11-41	240	11	7,575	3·47	262 98	D. Bevan & Sons	Parkview Commodore (306)
Hopelands Broken Belle	Jersey	81827	29-7-38	20-12-41	273	18	4,704	5·43	255·47	A. G. Scott	Melrose Sultan (6930)
Claremont Belle 24th	A.I.S.	....	12-6-39	13-8-42	273	17	6,186	4 08	252 66	Claremont Hospital for Insane	Wooroloo Jean 2nd's Guardian (4488)
Muresk Delia	Guernsey	9105	11-5-39	29-6-42	273	7	5,241	4·70	246·80	Muresk Agricultural College	Denmark Damon (2519)
Lenmoors Joan	A.I.S.	....	13-8-39	28-9-42	150	30	6,240	3·89	243·15	G. W. Marston	Longridge Blanche's Emblem (3344)
Claremont Maggie Morrison 33rd	do.	...	4-5-39	28-7-42	273	17	6,171	3 88	239·88	Claremont Hospital for Insane	Wooroloo Jean 2nd's Guardian (4488)
Lenmoors Milkmaid	do.	....	7-7-39	1-4-42	273	9	5,742	4·10	236·69	G. W. Marston	Longridge Blanche's Emblem (3344)
Claremont Mabel 14th	do	..	7-10-38	16-12-41	273	21	5,823	3·81	222 15	Claremont Hospital for Insane	Claremont Max Hero (3802)
Denmark Damon's Pekoe	Guernsey	8525	23-10-38	19-11-41	273	9	4,227	5·21	220·35	Denmark Research Station	Denmark Damon (2519)
Glanavon Melba 2nd	A.I.S.	...	16-4-42	21-4-42	120	35	4,710	3·83	180·48	D. Bevan & Sons	Glanavon Gold Boy (4830)
Denmark Velveteen	Guernsey	8541	24-7-39	18-9-42	30	35	1,050	4·42	46·50	Denmark Research Station	Koojan Ace's Goldseeker (3431)
COWS 3½ YEARS AND UNDER 4 YEARS STANDARD 290 LBS. BUTTER-FAT.											
Juadine Peerless Lily 13th	Jersey	76977	20-12-38	10-9-42	273	27·5	10,364	6·25	648·60	Miss L. G. Hancock	Austral Park Wonderful Standard (12423)
Juadine March Flower	do.	81988	5-3-39	30-9-42	273	27	9,786	5·20	509·66	Miss L. G Hancock	Austral Park Wonderful Standard (12423)

Wooroloo Dainty 2nd ...	A.I.S	28634	17-2-38	7-12-41	273	35	11,625	4·21	490·20	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Brookfields Betty	Guernsey	6833	30-10-37	29-10-41	273	19·5	7,918	5·49	435·31	P. G. Hampshire & Son	Brookfields Majesty (3254)
Grass Vale Twylish Lady	Jersey	76604	14-10-38	3-8-42	273	24	7,107	5·70	405·29	R. H. Rose	Grass Vale Gold Boy (14684)
Wooroloo Heather 2nd	A.I.S.	28644	6-11-38	23-6-42	273	10	8,490	4·35	369·88	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Brackenhurst Queen	do.	...	15-10-38	27-5-42	273	22	9,276	3·93	365·35	G. W. Marston	Thornleigh Champagne (930)
Glanavon Dahlia 9th	do.	....	19-1-39	9-5-42	273	26	8,778	4·12	362·40	D. Bevan & Sons	Glanavon Gold Boy (4830)
Glanavon Buttercup 3rd	do.	....	17-9-38	27-8-42	273	22	9,276	3·85	357·66	D. Bevan & Sons ..	Glanavon Gold Boy (4830)
Koojan Ideal's Dulcie	Guernsey	8310	25-10-38	14-6-42	273	14	6,282	5·65	355 17	A. W. Padbury ...	Glenburnie Ideal (Imp.) (2548)
Wooroloo Doreen 2nd	A.I.S.	28637	8-4-38	13-1-42	273	16	8,478	4·13	350·77	Wooroloo Sanatorium Farm	Glanavon Genius (3957)
Denmark Velvet	Guernsey	8540	23-8-38	12-7-42	273	16	6,648	4·93	327·75	Denmark Research Station	Denmark Auric (3313)
Amy	do.	....	25-9-38	11-7-42	273	13	4,989	6·13	306·20	P. Berridge	Willie
Crantock Primula's Tulip	Jersey	70900	15-3-38	7-11-41	273	15	5,295	5·74	304·05	Mrs. G. H. Burnside ...	Congelin Eminent's Golden (13623)
Glanavon Rosina 2nd	A.I.S.	....	17-9-38	23-7-42	273	8	7,614	3·94	300·16	D. Bevan & Sons ..	Glanavon Gold Boy (4830)
Wooroloo Hope 2nd	do.	....	2-9-38	5-4-42	273	13	6,729	4·09	275·60	Wooroloo Sanatorium Farm	Triumph of Pine Creek
Brookfields Queen 4th	Guernsey	6841	22-3-38	24-11-41	273	18	5,184	4·80	249·06	P. G. Hampshire & Son	Brookfields Baron (3936)
Glanavon Rosette 4th	A.I.S.	....	11-3-39	28-9-42	180	26	6,390	3·69	236·40	D. Bevan & Sons ..	Blacklands Jean's Supreme (1871)
Crantock Cream Countess	Jersey	....	20-8-38	29-5-42	180	9	3,450	5·57	192 33	Mrs. G. H. Burnside	Crantock Blonde's Napoleon (8207)
Greenmount Marinora's Model 2nd	do.	76623	27-5-38	27-4-42	210	15	3,660	4·92	180·27	A. G. Scott	Bellefaire Bonaparte's Bonetienne (9224)
Greenmount Marinora 4th	do.	76622	30-7-38	25-4-42	180	7	2,985	4·31	128·82	A. G. Scott	Bellefaire Bonaparte's Bonetienne (9224)
Denmark Mary Rose	Guernsey	6966	7-7-38	18-1-42	150	6	1,980	6·13	121·56	Denmark Research Station	Denmark Auric (3313)
Hopelands Silverbelle 4th ...	Jersey	81828	4-5-39	10-12-42	60	22	1,350	4·70	63·54	A. G. Scott .. .	Melrose Sultan (6930)
COWS 4 YEARS AND UNDER 4½ YEARS STANDARD 310 Lbs. BUTTER-FAT.											
Denmark Petal	Guernsey	....	4-10-37	29-11-41	273	11	7,983	6·58	525·95	Denmark Research Station	Koojan Golden Prosper (2283)
Grass Vale Golden Eve	Jersey	76601	23-6-38	8-7-42	273	19	8,022	5·77	462·88	R. H. Rose	Grass Vale Gold Boy (14684)
Glanavon Dahlia 7th	A.I.S.	....	23-3-38	5-9-42	273	21	10,998	4·06	447·01	D. Bevan & Sons ...	Glanavon Neptune
Glanavon Dell 4th	do.	..	23-3-38	23-7-42	273	17	11,061	3·92	433·86	D. Bevan & Sons ...	Glanavon Elliott (3955)
Denmark Golden Glory	Guernsey	6965	13-5-38	21-9-42	273	24	7,872	5·44	428·68	Denmark Research Station	Denmark Damon (2519)
Denmark Rosebud 2nd	do.	....	2-5-38	2-8-42	273	22	7,596	5·46	415·39	Denmark Research Station	Denmark Damon (2519)
Coogeley Jonquil	do.	6945	1-11-37	17-4-42	273	19	6,777	6·09	412·81	Denmark Research Station	Coogeley Judy's Goldmine (2621)
Wooroloo Jewel	A.I.S.	....	20-11-37	29-11-41	273	19	8,727	4·54	396·52	Wooroloo Sanatorium Farm	Wooroloo Duke 6th (3622)
Brookfields Honour	Guernsey	6836	8-9-37	13-3-42	273	23·5	6,925	5·67	393·17	P. G. Hampshire & Son	Koojan Ace's Majestic (2735)
Capel Daisy 2nd	A.I.S.	....	1-5-38	16-5-42	273	24·5	9,703	3·94	383·00	B. W Prowse ..	Capel Lottie's Reward (3782)
Glanavon Picture 4th	do.	....	16-7-37	31-12-41	210	35	9,465	3·90	369·27	D. Bevan & Sons .	Parkview Commodore (306)
Wooroloo Empress 2nd	do.	28639	24-11-37	21-3-42	273	21	8,943	4·08	365·76	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Wooroloo Poppy 4th ...	do.	28654	12-4-38	14-9-42	273	7	8,061	4·52	364·72	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Wooroloo Mary	do.	....	21-11-37	8-2-42	273	23	8,469	4·25	360·52	Wooroloo Sanatorium Farm	Parkview Guardian (2557)

HERD TESTING—*continued.*

Name of Cow.	Breed.	Herd Book No.	Date of Birth.	Date of Entry to Test.	No. of Days in Test.	Weight of Milk Last Day of Test.	Weight of Milk for Period.	Average Test.	Weight of Butter Fat for Period.	Owner.	Sire.
COWS 4 YEARS AND UNDER 4½ YEARS. STANDARD 310 LB. BUTTERFAT—*continued.*											
						lb.	lb.	%	lb.		
Travalgan Starbright 4th ...	Jersey	69418	26-10-37	31-3-42	273	16	6,288	5·63	354·15	W. H. & T. F. Robinson	Glen Iris Golden Oxford (12694)
Ferndale Jean 6th	A.I.S.	....	10-1-38	27-4-42	273	23	8,229	4·05	333·33	G. W. Marston ..	Tabbagong Hinkler (261)
Koojan Golden Ripple	Guernsey	7248	26-3-38	7-5-42	273	15	5,985	5·32	318·94	Denmark Research Station	Homestead Ace (1631)
Glanavon Pansy 4th	A.I.S.	. .	10-11-37	21-1-42	273	22	7,416	4·22	313·39	Burkit & Brown .	Blacklands Jean's Supreme (1871)
Travalgan Starbright 6th	Jersey	. .	31-5-38	16-6-42	273	17	6,021	5·19	312·94	W. H. T. F. Robinson	Glen Iris Golden Oxford (12694)
Tipperary Dove 10th	A.I.S.	....	25-3-38	17-5-42	273	5	7,170	4·11	298·83	W. G. Burges .	Blacklands Monarch's Commander (1877)
Yanget Pretty Maid 3rd	do.	....	8-7-38	24-9-42	273	7	6,681	4·41	295·06	W. G. Burges ..	Sunrise of Parkview (1875) (I.M.S.)
Tipperary Dove 9th . .	do.	. .	2-10-37	10-12-41	273	10	6,150	4·42	271·86	W. G. Burges ...	Blacklands Monarch's Commander (1877)
Westby Lupin 10th	do.	...	1-8-37	25-10-41	273	17	7,191	3·65	263·15	Burkitt & Brown ...	Telyarup Duke (956)
Glanavon Fairy 3rd ..	do.	..	21-4-38	7-5-42	273	7	5,931	4·26	252·95	D. Bevan & Sons ..	Blacklands Jean's Supreme (1871)
Yanget Beauty	do.	....	18-5-38	8-6-42	150	29	5,430	4·00	217·74	B. W. Prowse ..	Sunrise of Parkview (1875) (I.M.S.)
Chittering Fancy	do.	....	20-10-38	14-11-42	120	38	5,325	4·02	214·59	G. W. Marston	Brackenhurst Conquest (4624)
COWS 4½ YEARS AND UNDER 5 YEARS STANDARD 330 LBS. OF BUTTER-FAT.											
Grass Vale Design's Maggie	Jersey	71637	25-11-37	3-8-42	273	19	7,902	6·26	495·17	R. H. Rose	Grass Vale Gold Boy (14684)
Glanavon Charmer	A.I.S.	...	24-4-37	27-12-41	273	23	11,244	4·20	472·42	D. Bevan & Sons .	Parkview Commodore (306)
Glanavon Ettie	do.	...	25-2-37	14-12-41	273	12	10,326	4·16	429 91	D. Bevan & Sons .	Blacklands Jean's Supreme (1871)
Denmark Angeline	Guernsey	6956	4-7-37	4-4-42	273	17	7.041	5·61	395·44	Denmark Research Station	Koojan Golden Prosper (2283)
Brookfields Morden Lady 2nd	do.	6838	19-9-37	29-5-42	273	17·5	6,832	5·47	374·29	P. G. Hampshire & Son	Koojan Ace's Majestic (2735)
Crantock Napoleon's Daffodil	Jersey	75813	22-10-37	1-7-42	273	10	5,820	6 37	371·24	Mrs. G. H. Burnside . .	Crantock Blonde's Napoleon (8207)
Crantock Silk Socks ...	do.	70901	6-6-37	12-5-42	273	15	6,735	5·36	361·22	Mrs. G. H. Burnside . .	Congelin Emminent's Golden (13623)
Koojan Diana	Guernsey	7247	5-10-36	5-9-41	240	20	6,510	5·45	354·96	R. J. Giles	Koojan Ace's Aristocrat (2730)
Melbury Janet	A.I.S.	26505	18-7-37	17-5-42	273	20	8,280	4·27	354·01	G. W. Marston ..	Telyarup Roosevelt (1538)
Wooroloo Heather	do.	23247	5-11-37	16-9-42	240	12	8,190	4·23	347·04	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Brookfields Loyalty	Guernsey	6837	12-5-37	30-3-42	273	20·5	5,776	5·41	312·91	P. G. Hampshire & Son	Koojan Ace's Majestic (2735)
Warrawong Waybury	do.	8043	15-12-36	24-10-41	210	15	5,775	5·16	298·53	R. J. Giles	Nundorah Climax (1366)
Yanget Pretty Maid 2nd	A.I.S.	28697	28-10-37	17-9-42	273	5	6,315	4·45	281·51	W. G. Burges	Sunrise of Parkview (1875) (I.M.S.)
Westby Dahlia	do.	....	17-9-37	22-8-42	273	9	7,587	3·34	253·63	Burkitt & Brown ...	Telyarup Duke (956)
Crantock Golden Bell	Jersey	70896	13-8-37	16-6-42	240	5·5	4,515	5·05	228·24	Mrs. G. H. Burnside ...	Congelin Emminent's Golden (13623)

COWS 5 YEARS AND OVER—STANDARD 350 LBS. OF BUTTER-FAT.

Denmark Dawn 2nd	Guernsey	5439	21–3–35	27–11–41	273	28	9,354	6·43	601·49	Denmark Research Station	Koojan Golden Prosper (2283)
Glanavon Fairy	A.I.S.	20204	22–12–34	27–10–41	273	23	13,689	4·15	568·60	D. Bevan & Sons ...	Blacklands Jean's Supreme (1871)
Glanavon Rosina	do.	....	3–5–37	17–5–42	273	25	11,865	4·60	545·95	D. Bevan & Sons ...	Blacklands Jean's Supreme (1871)
Brookfields Lady Faith	Guernsey	4062	19–6–32	3–10–41	273	23	10,644	4·95	527·51	P. G. Hampshire & Son	Koojan Lord Barclay (1031)
Denmark Rosemary	do.	5451	7–6–36	21–11–41	273	18	7,194	7·13	512·99	Denmark Research Station	Koojan Golden Prosper (2283)
Glanavon Lulu	A.I.S.	....	25–10–36	17–5–42	273	26	11,558	4·33	500·94	D. Bevan & Sons ...	Blacklands Jean's Supreme (1871)
Glanavon Melba	do.	....	21–12–36	20–6–42	273	19	12,327	4·03	497·77	D. Bevan & Sons ..	Parkview Commodore (306)
Denmark Briar Rose	Guernsey	6959	15–8–37	29–9–42	273	26	9,333	5·32	496·93	Denmark Research Station	Denmark Illustrious (3320)
Wooroloo Bonnie	A.I.S.	18626	29–10–34	1–5–42	273	30	12,210	4·03	492·13	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Blacklands Ettie 9th	do.	9298	24–9–32	28–11–41	273	25	11,970	4·08	489·28	D. Bevan & Sons ...	Parkview Limelight (370)
Juadine Peerless Lily 9th	Jersey	62336	27–9–35	31–10–41	273	22	8,256	5·89	487·04	Miss L. G. Hancock ...	Juadine Sunshine (8212)
Lansdowne Morden Lady	Guernsey	3479	10–11–31	25–10–41	273	22	9,111	5·28	481·47	P. G. Hampshire & Son	Koojan Golden Broadcaster (1632)
Wooroloo Freda 2nd	A.I.S.	23245	9–10–35	25–6–42	273	10	12,135	3·94	478·66	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Melbury Red Rose	do.	12587	29–4–34	28–9–41	273	31	12,303	3·87	477·33	B. W. Prowse ...	Telyarup Roosevelt (1538)
Koojan Ace's Dulcie	Guernsey	5658	6–3–36	12–3–42	273	20	8,040	5·89	473·81	Denmark Research Station	Homestead Ace (Imp.) (1631)
Tipperary Fairy 3rd	A.I.S.	22905	1–9–36	2–10–42	273	26	11,003	4·21	463·40	W. G. Burges . .	Blacklands Monarch's Commander (1877)
Glanavon Tiny	do.	20212	25–9–34	10–5–42	273	26	11,448	4·03	461·62	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Koojan Ace's Daphne ..	Guernsey	5657	13–8–34	2–7–42	273	24	8,232	5·51	453·70	A. W. Padbury ..	Koojan Ace (2270)
Denmark Rosette	do.	6972	21–7–36	6–9–42	273	19	7,767	5·82	452·22	Denmark Research Station	Koojan Golden Prosper (2283)
Wooroloo Doreen	A.I.S.	23238	7–2–37	6–3–42	273	30	10,140	4·44	450·80	Wooroloo Sanatorium Farm	Wooroloo Duke 6th (3622)
Denmark Prosper's Rosa	Guernsey	4127	27–12–32	8–8–42	273	24	8,232	5·42	446·77	Denmark Research Station	Koojan Golden Prosper (2283)
Glanavon Daphne 3rd	A.I.S.	...	13–2–37	21–8–42	273	23	11,889	3·68	438·46	Burkitt & Brown ..	Parkview Commodore (306)
Colmyn Brown Maggie ...	Jersey	56859	27–6–35	1–10–42	273	20	8,205	5·29	434·10	Miss L. G Hancock ..	Colmyn Prince Victor (10492)
Denmark Rose Dame 4th ...	Guernsey	5447	13–3–35	4–12–41	273	28	8,349	5·14	429 62	Denmark Research Station	Koojan Golden Prosper (2283)
Wooroloo Lady Betty	A.I.S.	18634	3–8–34	7–3–42	273	29	10,212	4·17	426·81	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Denmark Golden Day	Guernsey	5440	29–7–35	9–11–41	273	23	8,079	5·27	426·48	Denmark Research Station	Denmark Damon (2519)
Koojan Ace's Jean	do.	5660	10–3–36	29–7–42	273	16	7,188	5·85	421·01	A. W. Padbury ..	Homestead Ace (Imp) (1631)
Denmark Diana	do.	6963	28–6–36	2–11–41	273	23	7,719	5·39	416·33	Denmark Research Station	Denmark Damon (2519)
Wooroloo Yvonne	A.I.S.	18639	25–2–35	22–1–42	273	27	10,801	3·79	410·31	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Juadine Juliet 8th	Jersey	44518	10–10–32	26–4–42	273	16·5	7,819	5·24	410·23	Miss L. G Hancock ...	Juadine Radiance (7598)
Denmark Prosper's Lady ...	Guernsey	3273	6–12–31	11–10–41	273	17·5	6,757	6·05	409·45	Denmark Research Station	Koojan Golden Prosper (2283)
Glanavon Gold 3rd	A.I.S.	....	24–8–36	31–1–42	273	20	9,480	4·19	397·92	D. Bevan & Sons .	Glanavon Le Nayler (320)
Leylands Queen	do.	17175	2–8–33	14–7–42	240	28	10,035	3·94	396·03	G. W Marston ..	Parkview Commodore (306)
Brackenhurst Dairymaid ...	do	19306	8–11–35	16–5–42	273	22	10,386	3·80	395·61	B. W. Prowse ..	Thornleigh Champagne (930)
Rosy Hill Mars	Jersey	64109	27–8–35	2–4–42	273	13	6,669	5·86	390·98	A. W. Padbury .	Rosy Hill Pearl's Chief (12136)
Glanavon Bluebell	A.I.S.	25157	1–3–36	17–4–42	273	26	8,950	4·36	390·42	G. W. Marston . .	Glanavon Nimrod (437)
Brookfields Beauty	Guernsey	6831	30–9–36	11–5–42	273	15	6,945	5·55	386·03	P. G. Hampshire & Son	Koojan Ace's Majestic (2735)
Crantock Cream Lass	Jersey	43542	7–6–31	21–3–42	273	23	6,579	5·75	378·71	Mrs. G. H. Burnside ..	Crantock Starbright's Montrose (5945)

HERD TESTING—*continued.*

Name of Cow.	Breed.	Herd Book No.	Date of Birth.	Date of Entry to Test.	No. of Days in Test.	Weight of Milk Last Day of Test.	Weight of Milk for Period.	Average Test.	Weight of Butter Fat for Period.	Owner.	Sire
COWS 5 YEARS AND OVER. STANDARD 350 LB. OF BUTTERFAT—*continued.*											
						lb.	lb.	%	lb.		
Wooroloo Empress	A.I.S.	23241	1-11-35	25-9-42	240	8	8,970	4·19	376·10	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Tipperary Maggie 4th	do.	18330	15-9-35	23-8-42	210	26	8,700	4·20	372·42	W. G. Burgess ...	Blacklands Monarch's Commander (1877)
Brookfields Bess	Guernsey	6832	8-9-37	8-10-42	273	16	6,948	5·29	367·63	P. G. Hampshire & Son	Koojan Ace's Goldseeker (3431)
Wooroloo Sunbeam	A.I.S.	23273	24-10-36	20-3-42	273	18	8,334	4·29	358·29	Wooroloo Sanatorium Farm	Wooroloo Triumph 4th (3627)
Milbank Joan 5th	do.	7411	12-1-32	25-7-42	210	26	9,435	3·78	356·67	G. W. Marston ..	Parkview Ruler (309)
Denmark Velda	Guernsey	6973	13-7-36	21-11-41	273	22	7,906	4·45	352·55	Denmark Research Station	Denmark Damon (2519)
Wooroloo Pearl 5th ...	A.I.S.	23264	1-10-36	25-5-42	273	9	8,517	4·13	352·15	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Westby Lupin 3rd	do.	18516	31-8-34	24-3-42	273	11	8,823	3·94	248·34	Burkitt & Brown	Telyarup Duke (956)
Glanavon Doris	do.	10923	1-8-32	20-2-42	273	9	8,772	3·94	345·66	D. Bevan & Sons ...	Villiers of Darbalara (2386)
Denmark Prosperette	Guernsey	....	17-5-36	11-10-41	273	13·5	6,625	5·19	344·40	Denmark Research Station	Denmark Damon (2519)
Wooroloo Betty 5th ...	A.I.S.	23232	8-1-37	10-6-42	273	16	8,178	4·19	343·45	Wooroloo Sanatorium Farm	Triumph of Pine Creek (2515)
Muresk Rosebud	Guernsey	4752	4-7-33	7-5-42	273	14	6,207	5·50	341·89	Muresk Agricultural College	Minnamurra Plaintiff (1318)
Glanavon Mayflower	A.I.S.	25184	22-4-37	31-7-42	273	11	9,153	3·72	341·02	D. Bevan & Sons ..	Parkview Commodore (306)
Muresk Mabel	Guernsey	7644	24-6-36	8-2-42	273	7	6,036	5·55	335·05	Muresk Agricultural College	Minnamurra Plaintiff (1318)
Denmark Wild Rose	do.	6974	1-7-36	4-12-41	273	14	6,252	5·33	333·28	Denmark Research Station	Koojan Golden Prosper (2283)
Westby Carnation	A.I.S.	18514	30-5-35	8-9-42	273	24	9,177	3·57	328·07	Burkitt & Brown ..	Telyarup Duke (956)
Westby Carnation	do.	18514	30-5-35	21-10-41	273	15	8,805	3·65	321·48	Burkitt & Brown	Telyarup Duke (956)
Glanavon Buttercup ...	do.	25158	4-5-36	22-3-42	240	13	7,320	4·16	304·68	D. Bevan & Sons ..	Blacklands Jean's Supreme (1871)
Glanavon Rosalie	do.	20210	12-2-35	12-8-42	273	18	8,109	3·66	296·93	D. Bevan & Sons .	Parkview Commodore (306)
Claremont Maggie 8th	do.	19604	12-11-35	12-7-42	273	18	7,524	3·88	292·59	Claremont Hospital for Insane	Wooroloo Persimmon (2972)
Muresk Trixie	Guernsey	6067	29-3-35	28-2-42	273	14	5,412	5·37	290·69	Muresk Agricultural College	Muresk Golden Chief (2925)
Westby Ulery	A.I.S.	15143	15-6-33	1-12-41	240	16·5	8,025	3·61	290·25	Burkitt & Brown	Telyarup Duke (956)
Denmark Rose Ophelia	Guernsey	5448	11-7-35	20-12-41	273	22	5,616	5·10	286·91	Denmark Research Station	Koojan Golden Prosper (2283)
Denmark Red Rose 9th	do.	4128	13-1-33	11-8-42	240	9	4,880	5·85	285·81	P. Berridge	Koojan Golden Prosper (2283)
Denmark Bonnie	do.	5437	22-7-35	19-3-42	273	13	5,559	5·10	283·68	Denmark Research Station	Denmark Damon (2519)
Westby Pearl	A.I.S.	15140	19-2-33	18-10-42	273	11	7,743	3·66	283·65	Burkitt & Brown ...	Telyarup Duke (956)
Muresk Jessie	Guernsey	7641	2-5-37	8-9-42	273	5	5,550	5·10	283·52	Muresk Agricultural College	Muresk Homestead (2075)

Crantock Napoleon's Primula 3rd	Jersey	66068	21-6-36	13-2-42	273	16·5	5,584	5·07	283·46	Mrs. G. H. Burnside	Crantock Blonde's Napoleon (8207)
Glanavon Sadie 2nd	A.I.S.	25192	9-2-37	24-4-42	150	46	6,960	4·05	281·91	D. Bevan & Sons	Glanavon Nimrod (437)
Greenmount Starbright's Marinora	Jersey	34841	31-5-30	19-10-41	240	14	5,430	5·15	280·11	A. G. Scott	Werribee Starbright's King (2602)
Moorlands Helena	do.	49635	18-5-33	7-3-42	210	24	5,535	4·88	270·15	A. G. Scott	Melrose Clarion (6931)
Greenmount Golden Wonder	do.	61975	28-3-35	22-7-42	210	13·5	5.775	4·67	269·76	A. G. Scott	Bellefaire Bonaparte's Bonetienne (9224)
Leylands Fairy	A.I.S.	17164	2-7-34	9-7-42	210	25	6,870	3·91	268·65	B. W. Prowse	Thornleigh Champagne (930)
Westby Lupin 10th	do.	28525	1-8-37	13-9-42	273	10	7,560	3·55	268·49	Burkitt & Brown	Telyarup Duke (956)
Muresk Desdemona	Guernsey	7633	31-5-36	3-7-42	273	9	5,547	4·83	268 04	Muresk Agricultural College	Muresk Homestead (2075)
Hopelands Silverbelle	Jersey	67044	24-7-34	10-11-41	240	7	5,182	5·04	261·54	A. G. Scott	Melrose Sultan (6930)
Hopelands Silverbelle 2nd	do.	62171	24-6-35	13-6-42	240	18	5,520	4·73	261·54	A. G. Scott	Melrose Sultan (6930)
Tipperary Dove 8th	A.I.S.	22904	6-10-36	2-5-42	273	7	6,321	4·11	260·04	W. G. Burges	Blacklands Monarch's Commander (1877)
Hopelands Helena	Jersey	62170	28-6-35	2-11-41	273	11 5	5,329	4·80	256·23	A. G. Scott	Preston Prospector (11024)
Tipperary Lady May 2nd	A.I.S.	18328	8-10-35	29-4-42	240	15	6,510	3·69	240·83	W. G. Burges	Blacklands Monarch's Commander (1877)
Westby Pearl	do.	15140	19-2-33	19-11-41	273	14	6,342	3·79	240·52	Burkitt & Brown	Telyarup Duke (956)
Hopelands Silverbelle 3rd	Jersey	67045	18-5-36	19-11-41	273	6	4,840	4·82	233·52	A. G. Scott	Melrose Sultan (6930)
Greenmount Bonetiennes Twinklette	do.	44202	6-8-33	23-1-42	273	12	4,536	5·03	228·72	A. G. Scott	Bellefaire Bonaparte's Bonetienne (9224)
Hopelands Biddy	do.	67043	17-10-35	26-6-42	210	9	4,290	4·91	210·90	A. G. Scott	Melrose Liberty (7973)
Hopelands Vera	do.	62172	7-11-34	17-12-41	240	5	4,410	4·63	204·45	A. G. Scott	Colmyn Captain Mac (5855)
Hopelands Belvedere 2nd	do.	....	10-10-32	27-7-42	180	17	4,620	4·41	203 76	A. G. Scott	Moorlands Carpus (7989)
Grass Vale Golden Cream 15th	do.	66783	3-9-36	19-5-42	240	6	3,540	5·62	199·08	A. G. Scott	Selsey Gay Boy (15134)
Greenmount Sweet Lass	do.	44204	14-7-33	26-6-42	150	20	4,515	4·29	194·13	A. G. Scott	Bellefaire Bonaparte's Bonetienne (9224)
Greenmount Golden Lass	do.	71653	30-9-36	18-9-42	120	24	3,660	4·46	174 36	A. G. Scott	Bellefaire Bonaparte's Bonetienne (9224)
Grass Vale Nora Lady	do.	66788	1-12-36	8-9-42	150	14	2,910	5·15	150·00	A. G. Scott	Selsey Gay Boy (15134)
Hopelands Silverbelle 3rd	do.	67045	18-5-36	19-10-42	120	13·5	2,715	4·56	123·96	A. G. Scott	Melrose Sultan (6930)
Greenmount Flash Maid	do.	61972	28-1-36	4-3-42	210	4	2,805	4·24	119·04	A. G. Scott	Greenmount Golden Flash (12736)
Devonia Silver Queen	do.	66223	18-11-35	13-12-41	90	22·5	2,295	4·32	98·19	A. G. Scott	Sabina Vale Silver Chief (13223)
Greenmount Marinette	do.	34840	24-5-31	17-5-42	180	7	2,100	4·26	89·49	A. G. Scott	Grantham Starbright's King (5796)
Norrie Peggy	A.I.S.	26939	14-4-35	11-7-42	60	35	2,220	3·90	86·67	W. G. Burges	Warwick Rufus (3595)
Hopelands Northern Biddy	Jersey	....	17-10-35	1-9-42	120	10	1,740	4·79	83·46	A. G. Scott	Travalgan Northern Noble (10124)
Brookfields Betty	Guernsey	6833	3-10-37	22-12-42	30	47	1,410	5·14	72·51	P. G. Hampshire & Son	Brookfields Majesty (3254)

The Hosier System.

A. B. ADAMS.

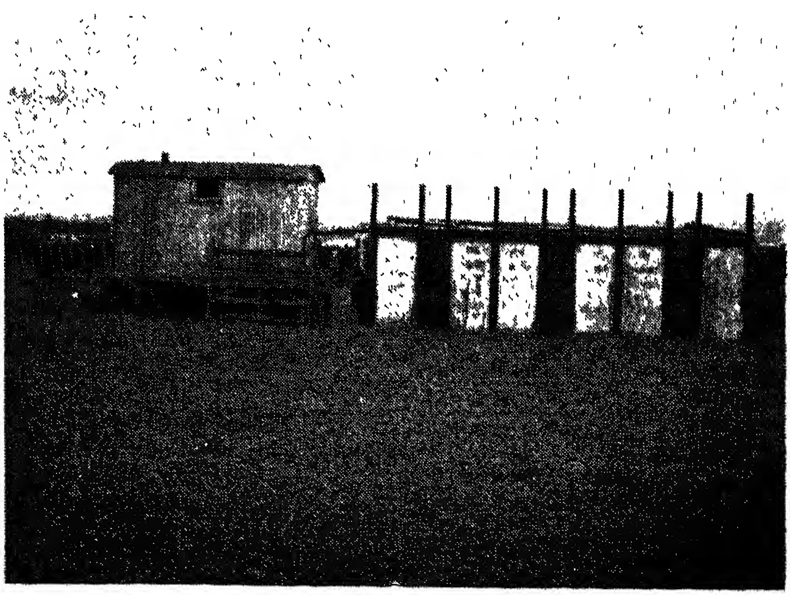
The Hosier system is a method of handling a dairy based on an open air system with transportable bails to take care of milking operations.

Mr. Hosier had a holding of several thousand acres on Salisbury Plain, Wiltshire. He wished to change from dry stock and sheep to whole milk production. To do this, and comply with the Health Acts in the normal way, it would have been necessary to erect buildings at a cost of several thousand pounds. To overcome this difficulty he thought out a plan of building bails on wheels. These allowed of milking under shelter on clean grass, and as soon as this area became fouled with droppings the bail was moved to fresh ground. When I visited him in June, 1937, Mr. Hosier had several units in action.

Each unit consisted of a portable shed with six bails, and a six unit milking machine. The engine was housed in a shepherd's hut, also on wheels. The yard was of wire and chestnut wood stakes. There were 60 cows in each herd unit in charge of a man and a boy.

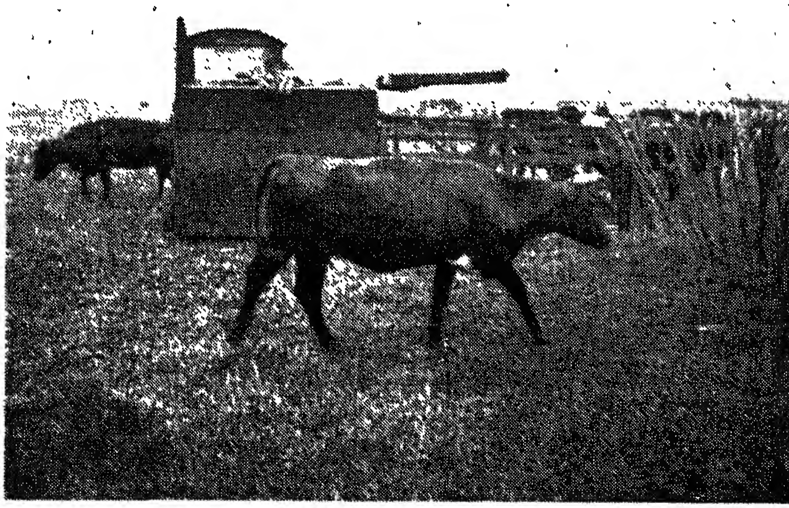
In operation the cows grazed the area adjacent to the bails. At milking time the cows were brought into the yard, milked in the bails, where they received their ration of concentrated food, and when milked out they were let out through the back of the shed by the dairyman pulling a shutter up and so allowing the cow to walk out. The layout and method will be seen in the illustrations.

There is a manger for the concentrate in front of each cow. It folds up as the shutter is raised. It was explained to me that at first the manger was on a door which opened, but the cows already let out were apt to hang around and interfere with those about to leave the shed. By folding the manger out of the way it got over this difficulty. The concentrate is held in hoppers above and to the side of the mangers, and the amount can be increased by pulling and pushing

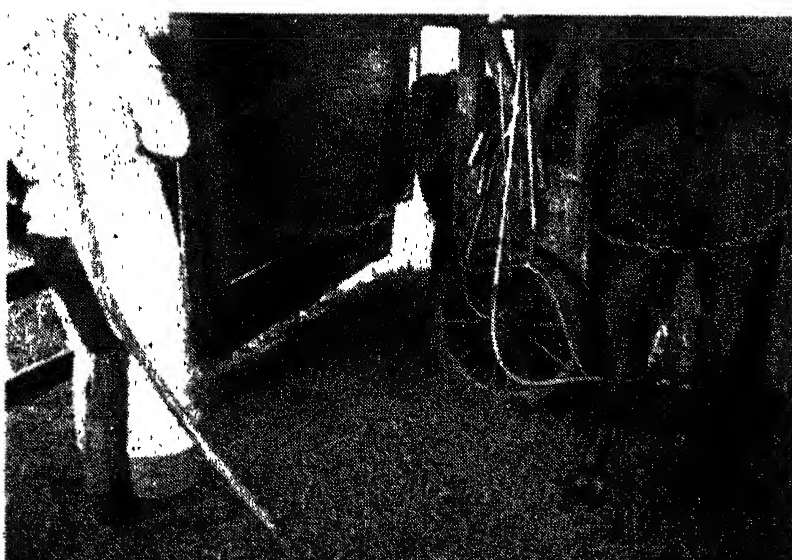


Rear view.

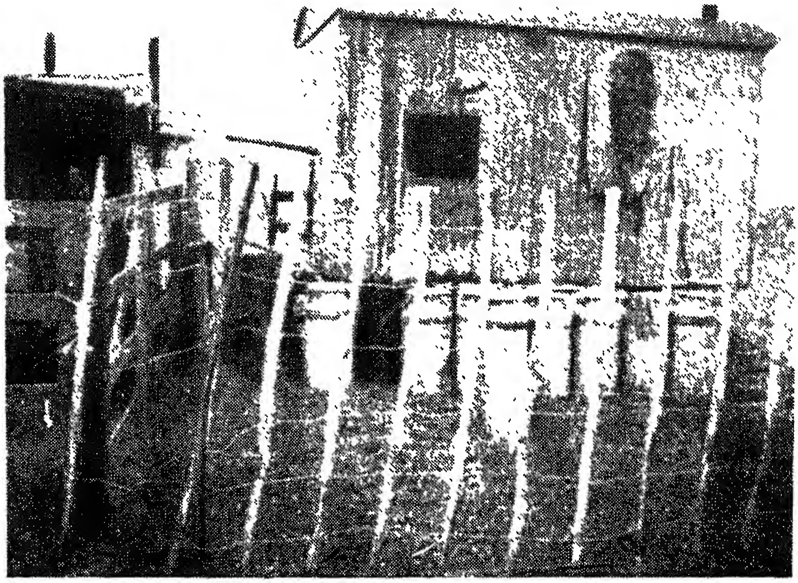
back a rod which controls the flow of the food into the manger. One pound was let into the manger for each time the rod was pulled out and pushed back. By this arrangement the concentrate was rationed according to each animal's production.



Side view, showing cow walking out.



Front view, showing part of shed, one cow leaving, another being milked.



Showing hut for engine and concentrates, also type of fence.

The Hosier system not only allows of clean production with a minimum of outlay, but at the same time greatly benefits the pasture by treading and added fertility.

It will be realised that treading is beneficial to light land; the system is not recommended for heavy clay soils.

It saves labour as no cleaning of sheds and casting out of manure is required.

To summarise:—

The Hosier system is suitable for medium and light soils and has the following advantages:—

(1) It saves outlay on buildings.
(2) It saves labour in dealing with droppings.
(3) It greatly improves the pasture where the outfit has been used.

Acknowledgment.

The following acknowledgment was omitted from the report of trials with Western Australian timbers for the manufacture of butter boxes in the March, 1943, issue of this Journal.

"The following assisted in carrying out the trial and the examination of the boxes and butter after storage:—

Messrs. J. O'Donnell, Gregson & Gorringe, Forestry Department; P. Quigley, Department of Commerce; N. M. Fox, Butter Manufacturers' Association; C. W. Thompson and J. Wood, South-West Co-operative Dairy Farmers; R. A. Paul and P. C. Cousins, Department of Agriculture.

Mr. F. Simper was responsible for the manufacture of the boxes, while the facilities at the South-West Co-operative Dairy Farmers' butter-cutting floor were made available by the courtesy of Mr. H. D. Gorrie, for the storage and examination of the butters."

Rubber Production in Relation to Western Australia.
Part II.

A. J. MILLINGTON.

Reference was made in the first part of this contribution to the possibility of producing natural rubber in Western Australia by means of the Mexican rubber shrub *Parthenium argentatum*. Experiments have also been conducted with the Russian dandelion, *Taraxacum Kok-saghyz*. Some millions of acres of this crop, by report, have been raised by the Russians, principally in the Eastern Ukraine and by the Germans in Poland. As mentioned previously, it is customary to mix a proportion of the natural product with the synthetic in automobile tyres and this, probably, is the reason for the cultivation of Kok-saghyz as a supplementary source of rubber. Since the plant is harvested in the second year of its growth, it is productive in a much shorter period than are most natural rubber plants and it therefore appeals as an emergency source.

Kok-saghyz root—about half natural size.

Description and Habitat.

Taraxacum Kok-saghyz is a native of the provinces which lie between Russia and Chinese Turkestan. A temperate climate with 26 inches of annual rainfall is required. The growth habit is similar to that of the local flatweeds, *Hypochoeris* spp., a rosette of leaves forming, from which arises flower heads. The rubber is formed in the peripheral layers of the rhizomes and for that reason plants with branching roots and hence greater surface areas, are preferred.

Cultivation and Processing.

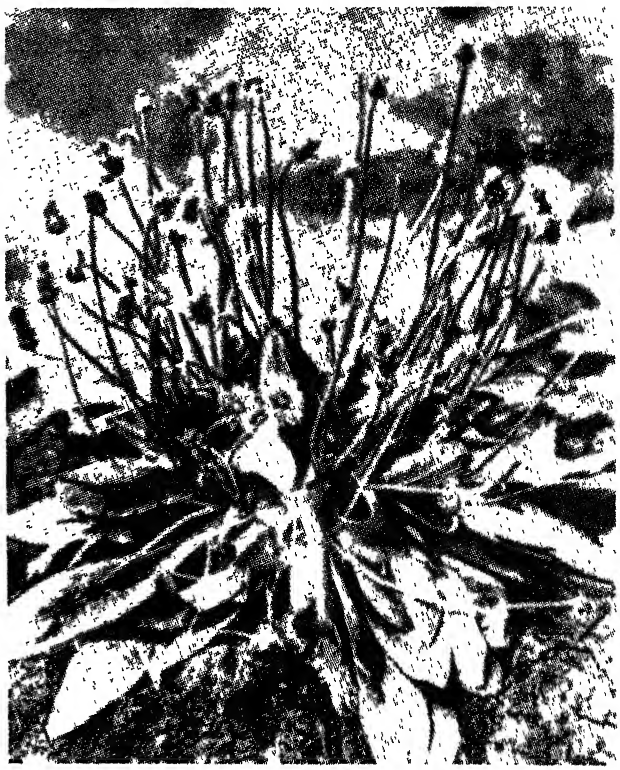
The crop is sown normally in shallow rows 13 to 18 inches apart, with 2 to 4 inches spaces between plants. Weeds must be vigorously suppressed, especially in the early stages by inter-row cultivation and hand weeding.

Seed is collected at the end of the first flowering season after which the leaves die and the plant becomes dormant. At the close of the second year, the whole plant is uprooted, the roots dried and ground to powder. The rubber is then separated in water or alkaline solution by flotation or centrifuging.

Experiments in W.A.

Seed of Kok-saghyz was obtained from Russia by the Australian Council for Scientific and Industrial Research and made available to this Department. Plantings were made at Margaret River, Busselton, Wokalup, Boyup Brook and Hamel in the South-West and also on the wheat belt research stations for observational purposes.

Germination was very much delayed in most instances, but such plants as did appear made little growth and died out in November. For successful cultivation in Western Australia, it appears that Kok-saghyz would require irrigation and also cultural conditions similar to those given to vegetables. Under present circumstances in view of the relatively low yields of rubber per acre, it does not appear to merit further experimentation.



Full grown Kok-saghyz plant in bloom.

Acknowledgments.

Grateful acknowledgment is made to the Deputy Conservator of Forests, Mr. T. N. Stoate, to Mr. Ross of the Forestry Department and to Messrs. A. L. Hamilton and J. M. Nelson of the Dairy branch for their assistance in this investigation.

The interest and enthusiasm of Dr. A. E. V. Richardson of C.S.I.R. made the experiments with both Guayule and Kok-saghyz possible, firstly by supplying seed and secondly, current literature dealing with these specific crops. Assistance has also been received from Professor Trumble of the Waite Institute, Adelaide, on technical matters pertaining to Guayule. The author would like to take this opportunity of expressing his thanks for their ready assistance and co-operation in these investigations.

Fodder Conservation.

M. Cullity and H. G. Cariss.

In a short article such as this, it is only possible to deal very broadly with this important phase of farming. In our dairying districts, for instance, fodder is wholly conserved for the feeding of the dairy herds, whereas in the wheatbelt, horses and sheep are the main consideration, with cattle normally of minor importance.

Though the requirements in the dairying districts and the wheatbelt areas differ, the underlying principles of fodder conservation are the same. In some areas almost the whole of the farm income is derived from stock. In others stock are of relatively minor importance.

The conservation of fodder is a very ancient practice as is illustrated by the biblical example of storing up reserves of fodder during the years of plenty in order to provide for the lean years. It can be regarded in the same light as the insurance which can be obtained against loss of buildings and plant. In the Northern Hemisphere the production of fodder supplies for the winter months is an integral part of the routine farm practice. The drought periods which occur annually in Australia are of a similar nature, but usually insufficient provision is made for them in the form of fodder conservation.

The carrying capacity of the farm is largely determined by the area of natural and sown pastures, which will vary from year to year in both quality and quantity. It may be increased by the sowing of fodder crops, particularly for early green feed.

It may be further improved by up to date methods of pasture development and management. These methods alone, however, are not altogether satisfactory, for they still leave the farmer depending on the vagaries of the season. Each year periods of high and low levels of nutrition occur, and in consequence, the carrying capacity is determined by the paddock feed available during the lean periods of the year unless reserves of fodder are available. Adequate quantities of conserved fodder will enable more stock to be safely carried during these lean periods.

Another important advantage of conserved fodder which is not always realised, is that it provides fodder of a better quality than is usually available in the paddock of the lean period. Better quality fodder means higher digestibility, higher protein, mineral and vitamin content, and in the case of silage, a succulent fodder for lactating animals.

The provision of better quality fodder will mean the maintenance of the health and condition of all stock, and higher production. Breeding stock kept under such conditions will produce strong and healthy offspring.

Conservation of fodder on the farm can be considered under two headings. The first is the need for seasonal reserves or seasonal supplies; the term reserves rather implying that they are only to be used when necessary. Actually the fodder is conserved for definite purposes—namely, for the feeding of the working horses over most of the year, and for other stock during that period when natural pastures in any normal season are deficient in quality and quantity. This latter is a drought period, which annually occurs in the agricultural areas of this State, when the breeding stock and young growing animals

require rations for growth and maintenance. Such provision avoids the necessity of reducing stock numbers, and enables the carrying capacity to remain at a more or less even level throughout the year. In the dairying districts these reserves are mainly used from about January to July, after which comes the flush period of green feed. One of the most important periods for the utilisation of these is after the first rains, when the paddock grazing is poor, and there is little body in the new green pasture. Hand feeding at this time also enables the young pasture to become firmly established. Under the second class may be considered drought reserves, which do not always receive the attention they should. This applies more particularly to the wheatbelt than to the dairy districts, where the rainfall is more assured. Reservations for this purpose provide fodder sufficient to enable the carrying capacity to be maintained through adverse seasons, and should therefore consist of at least sufficient for one year's feeding. In seasons like the one experienced in 1940-41, it is necessary to hand feed the farm stock through the greater part of the year. Such seasons, fortunately however, occur only at irregular intervals, and such drought reserves may not be required, at least to their full extent more than say, one year in ten. Whenever possible, however, these reserves should be built up to the original level.

In preparing a fodder conservation plan, due consideration must be given to the types of stock carried, the carrying capacity of a property at the time, and any probable increase. Provision must be made for ample quantity and quality of each type of fodder for proper rations, and the storage must be suitably situated in relation to the feeding of the animals.

Fodder may be conserved either as hay, silage, or grain, in all cases the material must be stored in such a manner that it is given the maximum protection from weather, fire and vermin hazards. Extra protection will be necessary if the fodder is to be stored over a long period, with the added safeguard of insurance.

HAY.

Hay is usually made either from cereals, or grasses and clovers. In the latter case, it is known as meadow hay. In the wheatbelt hay-making is mainly confined to the cereals wheat and oats, meadow hay being only of importance in the higher rainfall districts. When making cereal hay, the crop should be cut at such a stage that the maximum nutritive value is retained. Immediately after cutting, the hay should be stooked, preferably in large round stooks, in order to avoid the loss of nutrients by weather.

Stacking.

Stacking should be undertaken immediately the right stage of curing has been reached, that is when a straw from one centre of the stook will not show moisture when bent. The stacks should be well constructed, and if to be kept for long periods, should be thatched. When selecting the stack site, adequate provision should be made for protection from weather, fire and vermin hazards.

In the dairy districts a greater bulk of hay is made from clover and grasses. As meadow hay should have a high protein content, it is advisable that it should contain a high proportion of clover. The colour must be preserved. It has been shown that cows fed on fresh green fodder assimilate more calcium than they do from dried forage, and hay cured under protection from the sun was superior

to that cured under exposure to sunlight. Therefore, hay should not be unduly exposed to the sun after it is cured, and it is essential that every endeavour should be made to get the crop under cover as quickly as possible.

When to cut.

Subterranean clover should not be cut before the flowers appear at the ends of the runners, as at this stage the major proportion of the nutrients are distributed throughout the plant. Sufficient seed for reseeding will have already set from the flowers, which were nearer the centre of the plant. If the weather is favourable, raking into wind-rows should not be delayed more than one day. In good hay-making weather, the material from the wind-rows may be taken next day direct to the shed, stack, or baler. In the event of rain, it may be necessary to turn the wind-rows or cocks, but undue handling should be avoided, otherwise loss of leaf will occur. This loss should be avoided, as much as possible, as it is the leaf which has the highest nutritive value, containing more protein and less fibre.

Baling.

The baling of hay is becoming more popular, and where sufficient labour is available, it will be found to have several advantages over the usual haystack. The material is much easier to handle, and avoids much lost space when stored. The colour is preserved better, there is less waste, more exact quantities can be fed, and weather, fire, and vermin hazards are reduced.

SILAGE.

For the long or short term storage of fodders in a succulent, palatable and nutritious form, the ensilage of crops and of surplus pasture is of the greatest value. Silage may be stored for many years without deterioration, and provision for it should be made for dairy cattle and where export lambs are bred. Ensilage could easily become an integral part of the harvest routine.

Instead of commencing with hay-making, ensilage would be the first operation. Unfortunately, under our Western Australian conditions it is the relatively high labour requirements which deter many farmers from attempting to make silage. For silage the material should not be too mature, or otherwise a poor quality product will result.

To produce good silage, it is not essential to incur the expense of overhead silos. Excellent results can be obtained from pit or trench silos, or stack silage. Of these the trench silos are to be preferred in the wheatbelt, particularly for long term storage, and the stack silage for the dairy districts. In the dairy districts cheap timber silos are sometimes constructed, and have proved quite satisfactory.

When making silage, the material should be pressed tight to exclude air. With stacks, the edges should be trampled, and the centre left slack. Trench silos can be constructed cheaply with the aid of a plough and scoop. They should be situated on a high, well drained position, and protected from flood water.

The secret of making good silage lies in early cutting, quick carting, tight packing, and the exclusion of all air.

SUPPLEMENTARY CONCENTRATES.

Hay and silage, together with any available natural pasture, form a bulky portion of the ration. Working, breeding, and young stock, however, require in addition, a concentrated food of some sort. The most commonly utilised are the

cereal grains, although lupins and peas, which are usually fed direct in the paddock without harvesting and storage, are of much higher protein content. The cereal grains themselves can form an excellent maintenance ration, particularly for sheep, but they lack the bulk necessary for the proper working of the animal machine. As with the bulky fodders, the grains should be carefully stored, preferably in bulk in converted sheds or specially constructed tank silos. A silo to hold a thousand bags would cost approximately £100; one for 300 to 400 bags, £16 to £20.

Several small tanks are preferable to one or more large ones, and they should be conveniently placed. Storage in bags, except for very short periods, is unsatisfactory. The quantities conserved should be based upon the maximum requirements, and not on the possibility of paddock feed being always available.

Quantity to Feed.

For the wheatbelt the following is a suggested basis for quantities:—

(1) Sufficient cereal or meadow hay to supply all sheep at 1 lb. per day for four months.

(2) Sufficient grain to supply weaners and mated ewes with ½ lb. per head per day for 2-3 months.

(3) Sufficient silage for ewes breeding fat lambs at 1 lb. per day.

(4) For horses at heavy work 25 lb. chaff and 8-10 lb. of grain per day, on light work grain can be reduced.

(5) For milking cow 12 lb. chaff and 3 lb. grain depending on there being some pasture available.

It is estimated that for a 1,000 acre property carrying 14 horses, including 10 workers, five mixed cattle, and 550 sheep, including 250 breeding ewes, the normal annual requirements would be 60 tons hay and 300 bags of oats, or 250 bags of wheat, and provision for these would necessitate approximately 100 acres being set aside. In addition, the drought reserves must be maintained equivalent to one year's requirements.

In the dairy belt normal quantities to conserve are the equivalent of 2½ tons hay per cow, which includes a margin for the bull, horses, and young stock. The average cow can consume about 25 lb. good hay per day. For summer milking, in the absence of green pasture, 40 lb. silage per day should be fed plus about 15 lb. of good hay. High producing cows will require some concentrate, grain, etc., in addition, particularly where the quality of silage and hay is inferior.

To summarise, a certain level of hand feeding is necessary on every farm during the period of poor grazing to maintain the carrying capacity on a somewhat similar level to that of the period of good growth. If this is not done, some stock may have to be disposed of at very poor prices, or expensive fodders purchased. Reserves above this level are essential to provide against drought periods. These reserves must be considered as a form of stock insurance to guard against those abnormal years, which do occur on occasions, with disastrous results to farmers who have not made this provision.

Agricultural Broadcasts.

The following programme of Agricultural Talks has been arranged for the January-March quarter and will be broadcast from Stations 6WF and Regionals at 9.15 p.m. each Thursday.

Date.	Talk Prepared by:	Title.	Summary.
I.—FARMERS IN A CHANGING WORLD.			
Jan. 13	L. T. Jones, Agricultural Adviser	Phosphates in Agriculture	A brief historical survey of the use of phosphatic manures will be given, including consideration of the uses of phosphatic fertiliser and an account of world phosphate supplies.
Feb. 10	Prof. G. A. Currie	Agricultural Education	Desirable objectives in rural education will be discussed. Equal opportunity to enjoy all stages of education should be available to country and town children, and all hindrances to this ideal should be removed.
Mar. 9	A. B. Adams, Agricultural Adviser	Indian Agriculture	A brief account will be given of land tenure and agricultural production in India.
II.—TOPICAL ITEMS.			
Jan. 20 Feb. 17 Mar. 16	G. K. Baron Hay, Under Secretary for Agriculture, will discuss current events in agriculture		
III.—FARMERS' FORUM.			
Jan. 27 Feb. 24 Mar. 23	Discussion on topics submitted by farmers—Arranged by G. A. Currie, Professor of Agriculture, University of Western Australia		
IV.—TECHNICAL TALKS.			
Jan. 6	C. F. H. Jenkins, Government Entomologist	Some Summer Pests of the Vegetable Garden	A brief description, together with an outline of the life history of some of the commoner pests, will be given in conjunction with recommendations for their control.
Feb. 3	H. R. Powell, Superintendent of Horticulture	The War-time Marketing of Apples and Pears	The formation of the Apple and Pear Acquisition Scheme and its effect upon the economic position of W.A. apple and pear growers will be discussed.
Mar. 2	M. Cullity, Superintendent of Dairying	Wartime Problems in Dairying and Pig Raising	The problems, and what is being done to remedy them will be discussed.
Mar. 30	W. P. Cass Smith, Plant Pathologist	Some Plant Diseases of Economic Importance	The effects of plant diseases on the production of high priority crops will be outlined and some diseases will be discussed more fully. These will include Flax Rust, Damping-off of Vegetable seedlings, Citrus Brown Rot, and Black Rot of Cabbage.